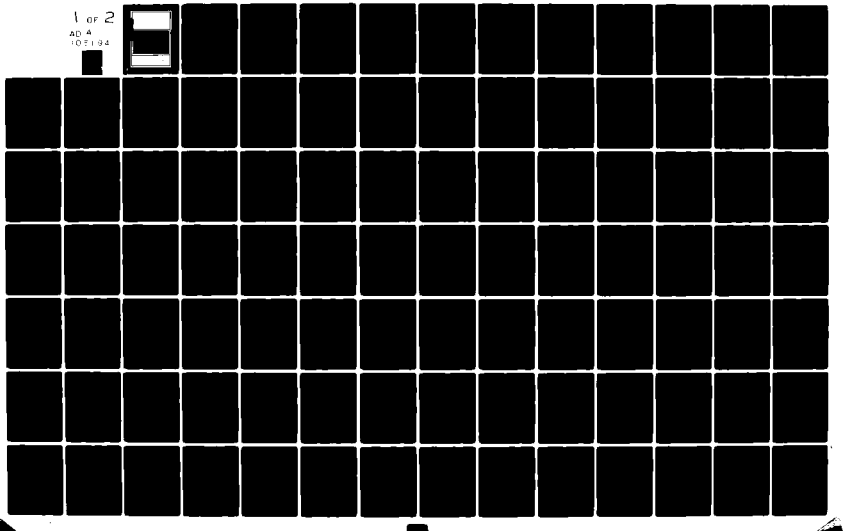
AD-A105 194 ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT--ETC F/G 14/2
AIR-BREATHING ENGINE TEST FACILITIES REGISTER.(U)
JUL 81 J H KRENGEL

UNCLASSIFIED AGARD-AG-269 NL

1 OF 2
AD A
105194



AGARD

ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT

7 RUE ANCELLE 92200 NEUILLY SUR SEINE FRANCE

AGARDograph No. 269

Air-Breathing Engine Test Facilities Register

NORTH ATLANTIC TREATY ORGANIZATION

AGARD-AG-269

NORTH ATLANTIC TREATY ORGANIZATION

ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT

(ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD)

AGARDograph No. 269

AIR-BREATHING ENGINE TEST FACILITIES REGISTER

Compiled by

Joachim H.Krengel

This AGARDograph was prepared at the request of the Propulsion and Energetics Panel of AGARD.

THE MISSION OF AGARD

The mission of AGARD is to bring together the leading personalities of the NATO nations in the fields of science and technology relating to aerospace for the following purposes:

- Exchanging of scientific and technical information;
- Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;
- Improving the co-operation among member nations in aerospace research and development;
- Providing scientific and technical advice and assistance to the North Atlantic Military Committee in the field of aerospace research and development;
- Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field;
- Providing assistance to member nations for the purpose of increasing their scientific and technical potential;
- Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community.

The highest authority within AGARD is the National Delegates Board consisting of officially appointed senior representatives from each member nation. The mission of AGARD is carried out through the Panels which are composed of experts appointed by the National Delegates, the Consultant and Exchange Programme and the Aerospace Applications Studies Programme. The results of AGARD work are reported to the member nations and the NATO Authorities through the AGARD series of publications of which this is one.

Participation in AGARD activities is by invitation only and is normally limited to citizens of the NATO nations.

Published July 1981

ISBN 92-835-1394-0

Printed by Technical Editing and Reproduction Ltd
Harford House, 7–9 Charlotte St, London, W1P 1HD

PREFACE

This Air-Breathing Engine Test Facilities Register was initiated by and prepared under the auspices of the AGARD Propulsion and Energetics Panel Subcommittee 01. The Subcommittee acknowledges the cooperation of the participating agencies in making this information available for publication. The Subcommittee is indebted to the author, Mr. Krengel, the DFVLR and the German Federal Ministry of Defence for donating the support which made this report possible.

It is observed that test facilities can be a large expense in the accomplishment of many research projects and development activities. Sometimes these facilities are only required on an occasional basis and construction of the test facilities by those who may wish to use them is not justified. The Propulsion and Energetics Panel intends for this compilation of the facility information to serve all scientists and engineers within the NATO Countries as a ready index of those test facilities which are available to them.

Only summary information is provided but contacts at each installation are given who can provide the desired detail.

James G. Mitchell
Chairman, Subcommittee 01

CONTENTS

INTRODUCTION

In context with its Symposium on "Turbine Engine Testing" it has been the aim of the Propulsion and Energetics Panel of AGARD to offer to the NATO community a survey on air-breathing engine test facilities which are presently available in NATO countries. It was concluded that the main interest is focussed on test facilities for research and development of aero-engines to be used as prime thrusters. Consequently production and post-overhaul acceptance test facilities are not to be found in this register, even though in some cases they have been used for special investigations.

In this book the reader will find a fairly complete survey of organisations which operate altitude and sea level test facilities for turbo-jet (including turbo-fan), ram-jet, and turbo-shaft engines. Though the book cannot claim comprehensiveness its initial working title was kept but the word register should not be understood in its prime sense and official meaning. Summary information about the test capacity of organisations and more detailed data for a number of individual test cells are offered and may be used for quick comparison and survey or for a preliminary selection of test facilities which the reader may wish to use in his research and development programmes.

There are two items to be observed when using the register :
The first one though randomly distributed is imminent to the applied system of raising and soliciting data. The user of this compilation will realise soon that depth and detail of information and data vary considerably between different organisations and for different test cells. This certainly is a deficiency of the register but one should bear in mind that participating in AGARD activities is voluntary and response to the inquiry made by a detailed question format was possible only to the extent of national or organisational desire and judgement. Most of the major testing centers have listed only their primary test cells which are used for development purposes.

The second item preferably applies to the facilities with altitude capability and may also be worth mentioning here. There usually are three factors which limit the operational range of a test cell : the electrical power available at the site, the compressor machinery for ram and exhaust purposes, and the piping system to and from the test cell. In many cases only the individual maximum values are quoted which in their direct combination would lead to unrealistic test cell capabilities. It was by no means possible to obtain and include triple sets of these data in order to characterize the capability of the individual test cell exactly. Since the actual range of operation does often also depend on the engine installed in the test cell an inquiry for a specific case will be the most effective approach. Very often a small alteration or adjustment leads to a satisfactory solution.

The compilation was effected upon request of the AGARD Propulsion and Energetics Panel, and Panel Members of almost all nations solicited data and helped in many ways. To them and to the engineers who submitted the data of the various organisations the author is very much indebted and wishes to express his thanks. He also acknowledges the permission of DFVLR and the German Federal Ministry of Defence to work on this AGARD activity.

Any major omissions or errors should be reported to the Propulsion and Energetics Panel Executive at AGARD Headquarters and corrections will be issued, if necessary, in due course.

1 LIST OF ORGANISATIONS

COUNTRY ORGANISATION LOCATION	TEST FACILITIES INCLUDED IN THIS REGISTER ALTITUDE TJ RJ TS	 SEA LEVEL TJ RJ TS	PAGE
CANADA	1 (1) [1]	10 14 + (1)	
Carleton University Gas Turbine Laboratory Ottawa, Ontario		1	2-1
Confederation College of Applied Arts & Technology, Aviation & Motive Power Dep. Thunder Bay, Ontario		1	2-2
National Research Council Canada Ottawa, Ontario	1 (1)	4 1	2-3
Pratt & Whitney Aircraft of Canada Ltd. St. Hubert and Longueuil, Quebec		4 8 + (1) (1)	2-4
Rolls Royce (Canada) Ltd. Lachine and Montreal, Quebec		2 2	2-5
Westinghouse Canada Ltd. Hamilton, Ontario		1	2-6
FRANCE	7 (1) (4)	14 (2)	
Centre d'Essais des Propulseurs Saclay	7 (1) (4)	3 (2)	2-7
SNECMA Sociête Nationale d'Etude et de Construction de Moteurs d'Aviation Moissy Cramayel		11	2-8
GERMANY (FEDERAL REPUBLIC)	1 (1) (1)	4 1 4	
DFVLR Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt e.V. Köln-Porz		1	2-9
MTU Motoren- und Turbinen-Union München GmbH München und Manching		4 4	2-10
Universität Stuttgart Institut für Luftfahrt-Antriebe Stuttgart	1 (1) (1)		2-11

[1] Number in brackets refers to test cells already included in preceding column.

1 LIST OF ORGANISATIONS

COUNTRY ORGANISATION LOCATION	TEST FACILITIES INCLUDED IN THIS REGISTER ALTITUDE TJ	RJ	TS	SEA LEVEL TJ	RJ	TS	PAGE
ITALY				1		4	
Alfa Romeo Aviazione Napoli						2	2-12
Costruzioni Aeronautiche G. Agusta Elicotteri Meridionali Frosinone						1	2-13
Fiat Aviazione S.p.A. Torino				1		1	2-14
UNITED KINGDOM	8	(3)	(1)	25		18 (4)	
Lucas Aerospace Ltd. Kenilworth, Warwickshire				1			2-15
National Gas Turbine Establ. Pyestock, Farnborough	5	(2)		1		(1)	2-16
Noel Penny Turbines Ltd. Coventry						5	2-17
Plessey Co. Ltd. Ilford, Essex						1	2-18
Rolls Royce Ltd.							2-19
Bristol	1	(1)		11			
Derby	2		(1)	6		3	
Hatfield						9	
Hucknall				6		(3)	
UNITED STATES	37	7	6	11		(4)	
Air Force Aeropropulsion Lab.,Wright-Patterson Air Force Base Ohio	3	(1)					2-20
AIResearch Manufacturing Co. Propulsion Engines Laboratory Torrance, California				2			2-21
Arnold Engineering De- velopment Center Arnold Air Force Station, Tennessee	11	1 (10)	(1)				2-22
General Electric Co. Cincinnati, Ohio	2						2-23
General Motors Corp. Detroit Diesel Allison Div. Indianapolis, Ind.	2		2 (1)				2-24
The Johns Hopkins Univer- sity Applied Physics La- boratory Laurel, MD.	4						2-25

1 LIST OF ORGANISATIONS

COUNTRY ORGANISATION LOCATION	TEST FACILITIES INCLUDED IN THIS REGISTER ALTITUDE TJ	RJ	TS	SEA LEVEL TJ	RJ	TS	PAGE
The Marquardt Co. Van Nuys, California	2	1 (2)					2-26
NASA, National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio	4	(2)					2-27
Naval Air Propulsion Center Trenton, New Jersey	3	(1)	4	4		(4)	2-28
Teledyne CAE Toledo, Ohio	2			2			2-29
United Technologies Corp.							2-30
Pratt and Whitney Aircraft Div.							
Florida Research & Development Center West Palm Beach, Fl.	3			3			
Andrew Willgoos Turbine Laboratory East Hartford, Connecticut	5						
Chemical Systems Divis. Sunnyvale, California		1					

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Carleton University
Department of Mechanical and Aeronautical Engineering
Gas Turbine Laboratory

ADDRESS : Ottawa K1S 5B6, Canada

CONTACT : Chairman, Department of Mechanical and Aeronautical Engineering

Phone 613-231-2639

2 TEST CELLS One test cell for turbo-shaft engines like Pratt and Whitney ST-6. Kahn water brake and fairly comprehensive instrumentation including air flow measurement available.

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Confederation College of Applied Arts & Technology
Aviation & Motive Power Department

ADDRESS : P.O. Box 398
Thunder Bay, Ontario
Canada

CONTACT : W.B. Troniak - for contractual purposes
N. Denetto - for technical information

Phone 807-577-5751 (both gentlemen)

2 TEST CELLS One test cell for turbo-shaft engines like Pratt & Whitney PT6A - 20.
Instrumentation similar to Twin Otter.

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : National Research Council of Canada
Division of Mechanical Engineering

ADDRESS : Ottawa, Ontario K1A OR6, Canada

CONTACT : Various, see test cell data section 6 + 7

2 TEST CELLS

Designation	Engine	Altitude	Mass Flow kg/s	Size W	H	L	Page
Altitude Test Chamber	TJ/TS	13.7 km	5.4	Diam 2.13 m		3.66 m	6-33
No 5 TC	TJ	Sea Level	136	4.6mx 4.6 m x 18.3 m			
No 1 TC	TJ	Sea Level	15.2	6 m x 5 m x 12 m			
No 4 TC	TJ	Sea Level	15.0	7.5mx 7.5 m x 18 m			7-16
No 2 TC	TS	Sea Level	5.0	6 m x 5 m x 17.4 m			
Propulsion Tunnel	TJ	Sea Level	1324	3 m x 6 m x 12 m			

3 AIR SUPPLY AND EXHAUST FACILITIES

3.1 SUPPLY 5000 kW compressor set (Propulsion Tunnel)
15 kg/s at 700 kPa[1)]
5 kg/s at 1000 kPa

COOLING 335 kW air refrigeration system

HEATING 5 kg/s at 1000 kPa up to 373 K

3.2 EXHAUST 2000 kW exhauster set (Propulsion Tunnel)
22.3 m^3/s suction capacity[1)]: 1.8 ÷ 5.4 kg/s
7 ÷21 kPa

[1)] same compressor

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Pratt & Whitney Aircraft of Canada Ltd.

ADDRESS : Longueuil, Quebec, Canada

CONTACT : Manager, Test Support Engineering

Phone 677-9411 Ext. 619

2 TEST CELLS

Designation	Engine	Altitude	Mass Flow kg/s	Size	Page
5 - 11	TJ	Sea Level			7-11
1 - 16	TJ	Sea Level	227		
1 - 17	TJ	Sea Level	227		
1 - 11A	TJ/TS	Sea Level			7-17
2 - 3	TS	Sea Level			
2 - 1	TS	Sea Level	11.4		
1 - 5	TS	Sea Level	11.4		
1 - 2	TS	Sea Level	8.2		
1 - 1	TS	Sea Level	385+		7-24
1 - 6	TS	Sea Level	385+		7-24
1 - 18	TS	Sea Level	385+		7-24
2 - 4	TS	Sea Level	385+		7-24

+ includes propeller mass flow

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Rolls Royce (Canada) Limited

ADDRESS : 9500 Cote de Liesse Road
Lachine, Quebec, H4Y 1B7

CONTACT : Director of Quality

Phone 514-631-3541

2 TEST CELLS

Designation	Engine	Altitude	Mass Flow kg/s	Size	Page
No 3 TB	TJ	Sea Level	150		
No 2 TB	TJ	Sea Level	100		
No 1 TB	TS	Sea Level	20		
T 64+	TS	Sea Level			7-20

+Prop Test Cell

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Westinghouse Canada Ltd.

ADDRESS : P.O. Box 510
Hamilton, Ontario
Canada

CONTACT : Manager of Product Reliability

Phone 416-528-8811 Ext. 2294

2 TEST CELLS One building with two water dynamometers

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Centre d'Essais des Propulseurs

ADDRESS : Saclay
91 406 Orsay
France

CONTACT : Monsieur le Directeur
(or as mentioned in sections 6 and 7)

2 TEST CELLS

Designation	Engine	Altitude	Mass Flow kg/s	Size Diam	Length	Page
R 5	TJ	20 km	375	5.5 m	30.0 m	6-21
R 3	TJ	20 km	200	3.5 m	18.0 m	6-22
R 4	TJ	20 km	200	3.5 m	18.0 m	6-22
S 1	TJ RJ TS	15 km	100	3.5 m	15.0 m	6-31
C 1	TJ TS	11 km	55	3.2 m	8.0 m	6-34
R 2	TJ TS	10 km		3.5 m		6-35
R 6	TJ TS	10 km		5.5 m		6-36
T x	TJ TS	Sea L.	Unlimited	55 m x 25 m concrete area		7- 5
T 1	TJ	Sea L.	1200	10 m x 10 m x 26 m		
H 9	TJ TS	Sea L.				7-18

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : SNECMA
Société Nationale d'Etude et de Construction
de Moteurs d'Aviation

ADDRESS : 77 550 Moissy Cramayel
France

CONTACT : M. le Chef du Département Essais aux Bancs
Direction Technique

Phone: 6.437.91.23 Ext. 3118

2 TEST CELLS

Designation	Engine	Altitude km	Mass Flow kg/s	Size H x W x L
W 1 C 7	TJ	Sea L.	500	8 m x 7 m x 22.4 m
W 2 C 7 [1)]	TJ	Sea L.	400	8 m x 7 m x 22.4 m
W 9 H 7	TJ	Sea L.	100	7.2 m x 7 m x 19 m
W 10 H 7	TJ	Sea L.	100	7.2 m x 7 m x 19 m
W 11 H 7	TJ	Sea L.	200	7.8 m x 7 m x 23.2 m
W 12 H 7	TJ	Sea L.	100	7.8 m x 7 m x 22 m
W 7 H 5	TJ	Sea L.	100	6.2 m x 5 m x 16.2 m
W 8 H 5	TJ	Sea L.	100	6.2 m x 5 m x 16.2 m
W 1 H 8	TJ	Sea L.	500	7.2 m x 7.5 m x 27 m
I Site No 3	TJ	Sea L.	Unlimited	Concrete surface area of 10.000 m^2
I Site No 5	TJ	Sea L.	Unlimited	Open air test bed

1) Reverse thrust capability

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Deutsche Forschungs- und Versuchsanstalt
für Luft- und Raumfahrt e.V. (DFVLR)

ADDRESS : Postfach 90 60 58
5000 Köln 90
Federal Republic of Germany

CONTACT : Institut für Experimentelle Strömungsmechanik

Phone: 2203-601-2278

2 TEST CELLS

Designation	Engine	Altitude	Mass Flow	Size H W L	Page
VMK	RJ	Sea Level up to 7.5 km+	90 kg/s	4 m x 4 m x 6 m	7-15

+depending on Mach-Number

3 AIR SUPPLY FACILITIES

SUPPLY: 1000 m^3 compressed dry air storage at 6000 kPa (about 70 Mg) for blow-down mode

10 kg/s at 6000 kPa continuous

HEATING: Regenerative heater: max. temperature 800 K
max. pressure 3500 kPa
capacity 60 kg/s for 1 min up to 800 K

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Motoren- und Turbinen-Union München GmbH

ADDRESS : Postfach 50 06 40
8000 München 50
Fed. Rep. of Germany

CONTACT : Dep. EVP
Development Test Facilities

Phone 89-1489-708

2 TEST CELLS

Designation	Engine	Altitude of Test St.	Mass Flow kg/s	Size H W L	Page
ETB 1	TJ	0.5 km	250/700+	6 m x 6 m x 20 m	
ETB 2	TJ	0.5 km	250/700+	6 m x 6 m x 20 m	
Open Air Test Bed	TJ	0.5 km	100	6 m x 6 m x 12 m (mobile hangar)	7-14
ETB 3	TS	0.5 km	2.5/5+	4 m x 4 m x 7 m	
ETB 4	TS	0.5 km	2.5/6+	4 m x 4 m x 7 m	
ETB 6	TS	0.5 km	3	4 m x 4 m x 7 m	
ETB 7	TS	0.5 km	2	4 m x 4 m x 7 m	
ETB 9	TJ	0.5 km	5		

+ Supply/Exhaust Capacity

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Universität Stuttgart

ADDRESS : Pfaffenwaldring 6
7000 Stuttgart 80 (Vaihingen)
Fed. Rep. of Germany

CONTACT : Direktor, Institut für Luftfahrt-Antriebe

Phone 711-7841 Telex 07 255 727

2 TEST CELLS

Designation	Engine	Altitude	Mass Flow kg/s	Size	Page
HPT	TJ RJ	20 km	70	Diam 3 m, Length 10 m	6-23
HPT[1)]	TS	16 km	70	3 m	10 m 6-23

[1)] alternative use

3 AIR SUPPLY AND EXHAUST FACILITIES

Compressor	volumetric flow	pressure ratio	entry temp.	application
AV 1	60 m^3/s	2.2 (max. 2.5)	303 K	exhaust only
AV 2	31 m^3/x	2.2 (max. 2.5)	303 K	ram + exhaust
AV 3	16 m^3/s	2.0 (max. 2.5)	303 K	ram + exhaust

Cooling turbine

	mass flow	pressure ratio	entry/exit temp.	application
LT 1	13 kg/s	up to 9	263 K/208-263 K	ram air cooling
LT 2	13 kg/s	up to 9	263 K/208-263 K	ram air cooling

Refrigeration system:

Two stage system capable of pre-cooling (before entering the cooling turbines) maximum mass flow 52 kg/s to 263 K during 4 hours.

Dryer

Absorption dryer may be used before passing the air flow into the second cooling stage of the refrigeration system.

Heater

Inlet air flows of 40 kg/s may be heated up to 423/450 K by a hot water heater which receives the heat either from a steamplant or from the exhaust gas cooler.

4 SUPPLEMENTARY INFORMATION

Höhenprüfstand für Turboflugtriebwerke,
Beschreibung der Anlage
ILA 80 A - 04

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Alfa Romeo Aviazione
Azienda di Pomigliano d'Arco

ADDRESS : 80 038 Pomigliano d'Arco
Napoli
Italy

CONTACT : Technical Director

Phone 8841344 Telex 710083 ALFAPO

2 TEST CELLS

Designation	Engine	Altitude	Mass Flow	Size H x W x L	Page
Hangar TB	TS	Sea L.		6 m x 5 m x 14 m	7-27
Dynamom. Test Bed	TS	Sea L.		4 m x 5 m x 7 m	

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Elicotteri Meridionali

ADDRESS : Via G. Agusta 1
03100 Frosinone
Italy

CONTACT : Allison 250 Technical and Service Manager

Phone 0775-82801 Telex 611377

2 TEST CELLS

Designation	Engine	Altitude	Mass Flow	Size H x W x L
	TS	Sea Level	3 kg/s	8 m x 7 m x 9 m

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Fiat Aviazione S.p.A.

ADDRESS : Corso Ferrucci 122
10100 Torino
Italy

CONTACT : Direzione Progettazione

Phone 11 - 332133
Telex FIATAP 221 564

2 TEST CELLS

Designation	Engine	Altitude	Mass Flow	Size H	W	L
Fiat Sangone Cell No 6	TJ	Sea Level	400 kg/s	10 m	9 m	27 m
Fiat Sangone Cell No 9	TS	Sea Level		4 m	4.4 m	10 m

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Lucas Aerospace Ltd.

ADDRESS : Oldwich Lane, Fen End
Kenilworth, Warwickshire
England

CONTACT : Engineer in Charge, Engine Management Division

Phone Berkswell 32761 Telex 338781

2 TEST CELLS

Designation	Engine	Altitude	Mass Flow	Size
Honiley	TJ	Sea Level		5.5 m x 7.4 m x 21 m

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : National Gas Turbine Establishment

ADDRESS : Pyestock, Farnborough, Hants GU 14 OLS England

CONTACT : Director, NGTE

Phone 0252-44411 Telex 858 231

2 TEST CELLS

Designation	Engine	Altitude	Mass Flow kg/s	Size Diam	Length	Page
Cell 4	TJ/RJ	0 ÷ 30 km+	270	9 m	21 m	6- 4
Cell 1	TJ/RJ	0 ÷ 30 km+	180	3.7 m	37 m	6- 5
Cell 3	TJ/RJ	0 ÷ 19 km	270	6 m	24 m	6-28
Cell 3 W	TJ	0 ÷ 18 km	630	7.5 m	17 m	6-29
Cell 2	TJ/RJ	0 ÷ 17 km	180	3.7 m	37 m	6-30
Glen Test House	TJ/TS	Sea Level	200			

+Supersonic free jet with spill diffusion

3 AIR SUPPLY AND EXHAUST FACILITIES

NGTE has a central air supply/exhaust system serving all the test cells with local additional heating/cooling of the inlet air at the cells.

3.1 SUPPLY

Compressors: 8 GEC centrifugal sets which can be used either as compressors or exhausters at 9/1 or 3/1 pressure ratio.
As compressors: 90 kg/s at 910 kPa abs per set
or 122 kg/s at 304 kPa abs per set

Maximum power supply to site allows five sets to be r . as compressors (135 MW)
Two axial compressors each giving 27 kg/s at 600 kPa abs.

Cooling: Minimum inlet temperature at cell:
Cell 1 - ambient
Cell 2 - ambient
Cell 3 - 41 kg/s at 200K from expansion turbine
Cell 3W-363 kg/s at 236K from cold store system
Cell 4 - ambient

Heating: Maximum inlet temperature at cell:
Cell 1 - 483K + 3 MW trimming heater
Cell 2 - 483K + 3 MW trimming heater
Cell 3 - 255 kg/s at 480 K plus 45 kg/s at 870K from oil fired heater
Cell 3W- ambient
Cell 4 - 255 kg/s at 480 K plus 45 kg/s at 870 K from oil fired heater

3.2 EXHAUST

8 GEC centrifugal sets which can be used as exhausters:
9.4 kg/s at 11.3 kPa abs per set in 9/1 pressure ratio arrangement, or:
37 kg/s at 33.8 kPa abs per set in 3/1 pressure ratio arrangement

One axial exhauster: 25 kg/s at 11.3 kPa abs with maximum driving power of 25 MW
(No 10 m/c)
One axial exhauster: 11.3 kg/s at 7.8 kPa abs with maximum driving power limit of 27 MW
(No 9 m/c)

4. SUPPLEMENTARY INFORMATION

General description and background: Engineering, June 14,21,28 1957

Cell 3W: An altitude test facility for large turbofan engines
P F Ashwood,Journal of Aircraft,Vol.10,No 8,August 1973

Cell 4: Free jet testing of supersonic intake/engine combination
P F Ashwood,Journal Royal Aeronautical Society,
Vol.74,pp 205-212, 1970

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Noel Penny Turbines Ltd

ADDRESS : Siskin Drive, Toll Bar End
Coventry CV 3 4 FE
England

CONTACT : A. F. Varney

Phone 0203-301528
Telex Penny 311 065

2 TEST CELLS Five test cells suitable for sea-level testing of turbo-shaft engines (maximum power 2575 kW).
The number of test cells may rise to eight within the near future.

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Plessey Co. Ltd.

ADDRESS : Vicarage Lane
Ilford, Essex
England

CONTACT : Test Facility Manager
Deputy Engineering Executive

Phone Titchfield 43031 Ext. 2428/2401

2 TEST CELLS

Designation	Engine	Altitude	Mass Flow	Size H W L	Page
Plessey Aerospace Test Fac. (6 cells)	TS	Sea Level	4.5 kg/s	2.7 m x 4.6 m x 9.1 m	7-26

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Rolls Royce Ltd

1. Aero Division Bristol (RR - BR)

ADDRESS : P.O. Box 3
Filton, Bristol
England

CONTACT : Assistant Chief Engineer
Test Engineers Department
Phone Bristol 693872 Ext. 384

2. Aero Division Derby (RR - DE)

ADDRESS : P.O. Box 31
Derby DE 2 8BJ
England

CONTACT : Phone 0332-42424 Telex 37645

3. Hatfield (RR - HA)

ADDRESS : Manor Road
Hatfield
England

CONTACT : RR Site Manager
Phone Hatfield 63830

4. Hucknall (RR - HU)

ADDRESS :

CONTACT :

2 TEST CAPACITY OF ORGANISATIONS

2 TEST CELLS

	Designation	Engine	Altitude km	Mass Flow kg/s	Size H	W	L	Page
BR	TP 131 A	TJ/RJ	27.4	182	Diam 3.05m x		24.4 m	6 - 7
DE	ATF Cell 1	TJ/TS	21.3	272	Diam 3.81m x		11.5 m	6 - 19
DE	ATF Cell 2	TJ	21.3	272	2.75m x	3.81m x	11.5 m	6 - 19
HU	TB No 9	TJ	Sea Level	unlimited	open air test bed (accept large fan engines)			7 - 1
BR	METS A+B	TJ	Sea Level	unlimited	6300m^2 concrete area			7 - 2
HU	TB No 5	TJ/TS	Sea Level	unlimited	open air test bed (no large fan engines)			7 - 6
HU	TB No 7	TJ/TS	Sea Level	unlimited	open air test bed			7 - 7
DE	TB No 48	TJ	Sea Level	1000	12 m x	10 m x	64 m	
DE	TB No 49	TJ	Sea Level	1000	12 m x	10 m x	64 m	
HU	TB No 10	TJ	Sea Level	907				
BR	TP 105	TJ	Sea Level	536	13.4mx	11.9m x	21.0m	7 - 10
BR	TP 137	TJ	Sea Level	536	13.4mx	11.9m x	24.0m	7 - 10
BR	TP 107	TJ	Sea Level	454	7.3mx	7.0m x	11.6m	
BR	TP 103	TJ	Sea Level	304	7.8mx	10.5m x	21.9m	
BR	TP 104	TJ	Sea Level	304	7.8mx	10.5m x	21.9m	
BR	TP 140	TJ	Sea Level	272	9.8mx	9.4m x	44.2m	
BR	TP 141	TJ	Sea Level	272	9.8mx	9.4m x	45.4m	
HU	TB No 8	TJ/TS	Sea Level	204	6.1mx	6.1m x	6.1m	7 - 12
DE	TB No 41	TJ	Sea Level	180	7.6mx	7.3m x	17.4m	
DE	TB No 42	TJ	Sea Level	180	7.6mx	7.3m x	17.4m	
DE	TB No 43	TJ	Sea Level	180	7.6mx	7.3m x	17.4m	
DE	TB No 44	TJ	Sea Level	180	7.6mx	7.3m x	17.4m	
HU	TB No 2	TJ	Sea Level	180	7.6mx	7.3m x	15.2m	
BR	TP 108	TJ	Sea Level	170	7.0mx	7.0m x	21.0m	
BR	TP 131 E	TJ	Sea Level	77	6.4mx	8.5m x	20.7m	
BR	TP 125	TJ	Sea Level	77	2.7mx	5.5m x	13.1m	
DE	Hangar H	TS	Sea Level	1800	7.9mx	7.9m x	44 m	7 - 19
DE	TB No 16	TS	Sea Level	26	5.2mx	5.2m x	22 m	
DE	TB No 18	TS	Sea Level	26	5.2mx	5.2m x	22 m	
HA	TB No 16	TS	Sea Level		7.6mx	4.9m x	11.6m	7 - 21
HA	TB No 15	TS	Sea Level		2.0mx	4.9m x	8.2m	7 - 22
HA	TB No 19	TS	Sea Level		2.0mx	4.9m x	8.2m	
HA	TB No 12	TS	Sea Level		2.7mx	4.9m x	6.0m	7 - 23
HA	TB No 13	TS	Sea Level		2.7mx	4.9m x	6.0m	7 - 23
HA	TB No 13 A	TS	Sea Level		2.7mx	4.9m x	6.0m	7 - 23
HA	TB No 20	TS	Sea Level		2.7mx	4.9m x	6.0m	
HA	TB No 11	TS	Sea Level		5.1mx	4.9m		
HA	TB No 21	TS	Sea Level		4.9mx	4.8m x	42.7m	7 - 25

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Air Force Aero Propulsion Laboratory

ADDRESS : Wright-Patterson Air Force Base
Ohio 45433
USA

CONTACT : Technical Area Manager
AFWAL / POTC

Phone 513 ~ 255 - 2121

2 TEST CELLS

Designation	Engine	Altitude km	Mass Flow kg/s	Size
Ramjet	TJ/RJ	16.8	109	
TC 21	TJ	15.2	109	Diam 3.0 m x 5.2 m
TC 24	TJ	15.2	109	Diam 3.7 m x 6.1 m
Sea Level Eng.Test Fac.	TJ	Sea L.	1045	13 m x 10 m x 27 m

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : AIR esearch Manufacturing Co.
Propulsion Engines Laboratory

ADDRESS : 20 000 Van Ness Avenue
Torrance, California, USA

CONTACT :

2 TEST CELLS

Two sea level development test cells both accepting turbojet engines producing up to 111 kN thrust.
Test cell inner dimensions are 6.7 m x 7 m x 25.9 m

The test cells are equipped with the real time engine guard system (50 channels: 20 temperatures, 20 pressures, 6 frequencies, 4 misc.). and a data logging system (300 temperatures, 552 pressures, 36 differential pressures, 10 frequencies, and 60 miscellaneous). Also fully automatic control of engine testing is possible by T-PEC (taped program engine controller).

3 -

4 SUPPLEMENTARY INFORMATION

R. S. OLIVE Modern Jet Engine Development Facility
ASME Paper 71-WA/GT-6

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Arnold Engineering Development Center

ADDRESS : Arnold Air Force Station
Tennessee 37389
USA

CONTACT : AEDC/DOX

2 TEST CELLS

Designation	Engine	Altitude km	Mass Flow kg/s	Size H W L	Page
PWT 16 S	TJ/RJ	47.2		4.9 m x 4.9 m x 12.2 m	6 - 1
ASTF C_2 [1)]	TJ/RJ	30.5	1250	Diam 8.5 m x 25.9 m	6 - 2
APTU	RJ	30.5	863	Diam 1.2 m x 12.8 m	6 - 3
ASTF C_1 [1)]	TJ/RJ	30.5	660	Diam 8.5 m x 25.9 m	6 - 2
PWT 16 T	TJ/RJ	27.5		4.9 m x 4.9 m x 12.2 m	6 - 6
J-1	TJ/RJ	24.4	636	Diam 4.9 m x 21.9 m	6 - 8
J-2	TJ/RJ	24.4	636	Diam 6.1 m x 21.0 m	6 - 9
T-1	TJ/RJ	24.4	363	Diam 3.7 m x 22.9 m	6 - 10
T-2	TJ/RJ/TS	24.4	363	Diam 3.7 m x 20.7 m	6 - 11
T-4	TJ/RJ	24.4	363	Diam 3.7 m x 16.8 m	6 - 12
T-6	TJ	24.4	170	Diam 0.9 m x 5.5 m	6 - 15
T-5	TJ/RJ	24.4	41	Diam 2.1 m x 5.2 m	6 - 17

3 AIR SUPPLY AND EXHAUST FACILITIES

The AEDC is comprised of various highly versatile facilities of which the following are relevant for this register:

1. Propulsion Wind Tunnel 16 Supersonic PWT 16 S
2. Propulsion Wind Tunnel 16 Transonic PWT 16 T
3. Aerodynamic and Propulsion Test Unit APTU
4. Engine Test Facility - Basic (T-Cells) ETF - B
5. Engine Test Facility - Addition (J-Cells) ETF - A
6. Aeropropulsion Systems Test Facility ASTF

Each facility is equipped with its individual supply and exhaust system which may be linked to a certain extend in support of the test cells listed above.

3.1 SUPPLY

			air mass flow kg/s	pressure kPa
Compressors	ETF-B	4 centrifugal (one stage)	82	275
	ETF-A	3 axial flow (one stage)	200	275
	ETF-A+B	(two stage)	215	930
	ASTF	6 axial flow (two stage) (4 x 20.1 MW 2 x 39.1 MW)	500	1034
		(one stage)	660	275
Storage	APTU	630 m^3 high pressure air storage reservoir containing about 204.000 kg at 27.6 MPa		
Heating	ETF-A	indirect fired heater maximum temperature	672 K	
		air mass flow	227 kg/s	
	ASTF	heat input to process air	287.5 MW	
	APTU	regenerative storage heater maximum matrix temperature	1366 K	
		max. air mass flow	116 kg/s	
		vessel design pressure plus vitiated air heater	34.5 MPa	

Cooling	ETF-B	continuous mech. refrigeration	3.33 MW
	ETF-A	continuous mech. refrigeration	8.54 MW
	ASTF	electromechanical refrigeration plus five refrigeration turbines each 136 kg/s from 250 K to 195 K	28.7 MW

3.2 EXHAUST

		mass flow kg/s		pressure kPa
ETF-B	6 centrifugal compressors	204	from	30.3
ETF-A	2 axial flow compressors			
ASTF	8 axial flow compressors	136	from	4.1
	(each 20.5 MW)	272	from	12.4
	4 axial flow compressors (each 32.8 MW)	1133	from	31.0

(Suction capacity of PWT plenum evacuation compressors may be used for exhaust augmentation of ETF-B and ETF-A)

4. SUPPLEMENTARY INFORMATION

AEDC Test Facilities Handbook, June 1979

J.G. Mitchell — The Airo-Propulsion Systems Test Facility
AIAA-Paper No. 72-1034

J.R. Rickard
M.W. Lawley — Instrumentation and Control for a Large Engine Test Facility

to be found in
Imaginative Engineering through Education and Experience.
Proc. of the Southeast Region 3. Conference
Williamsburg, Va. April 4-6, 1977,
New York, Institute of Electrical and Electronics Engineers Inc.
1977, p 511-514

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : General Electric Co.

ADDRESS : Cincinnati, Ohio 45215
USA

CONTACT :

2 TEST CELLS

Designation	Engine	Altitude km	Mass Flow kg/s	Size
TC-43	TJ	24.4	454	Diam 5.2 m x 17.1 m
TC-44	TJ	24.4	182	Diam 5.2 m x 17.1 m

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : General Motors Corporation
Detroit Diesel Allison Division

ADDRESS : 2355 S. Tibbs Avenue
Indianapolis, Indiana 46241
USA

CONTACT :

2 TEST CELLS

Designation	Engine	Altitude km	Mass Flow kg/s	Size
871-2	TS	20	54.5	Diam 6.1 m x 12.2 m
881	TJ	15.2	190	Diam 5.5 m x 20.7 m
873	TJ/TS	13.7	45.4	Diam 4.3 m x 12.2 m
885	TS	7.6	2.5	Diam 5.5 m x 14.6 m

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : The Johns Hopkins University
Applied Physics Laboratory

ADDRESS : Laurel, Maryland 20810
USA

CONTACT :

2 TEST CELLS

Designation	Engine	Altitude km	Mass Flow kg/s	Size H W L
TC-1	RJ	45.7	68	3.7 m x 3 m x 12.2 m
TC-2	RJ	45.7	68	3.7 m x 3 m x 12.2 m
TC-3	RJ	45.7	68	3.7 m x 3 m x 12.2 m
TC-4	RJ	45.7	68	3.7 m x 3 m x 12.2 m

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : The Marquardt Co.

ADDRESS : 16 555 Saticoy Street
Van Nuys, California 91409

CONTACT :

2 TEST CELLS

Designation	Engine	Altitude km	Mass Flow kg/s	Size
TC-8	TJ/RJ	52	363	Diam 4.3 m x 24.4 m
TC-2	TJ/RJ	24.4	182	Diam 3.0 m x 18.3 m
TC-7	RJ			Diam 1.8 m x 9.1 m

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : National Aeronautics and Space Administration
Lewis Research Center

ADDRESS : 21 000 Brookpark Road
Cleveland, Ohio 44 135
USA

CONTACT :

2 TEST CELLS

Designation	Engine	Altitude km	Mass Flow kg/s	Size	Page
PSL-4	TJ	21.3	340	Diam 7.3 m x 11.6 m	6-18
PSL-3	TJ	21.3	340	Diam 7.3 m x 11.6 m	6-18
PSL-1	TJ/RJ	21.3	204	Diam 4.3 m x 7.3 m	6-20
PSL-2	TJ/RJ	21.3	204	Diam 4.3 m x 7.3 m	6-20

3 AIR SUPPLY AND EXHAUST FACILITIES

SUPPLY		air mass flow kg/s	pressure kPa
Central Supply System		217	414
		174	1138
		17.2	3206

Heating 2 J57 heat exchangers
127 kg/s to 922 K (max. pressure 1138 kPa)

Cooling 3 turboexpanders
181 kg/s to 205 K

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Naval Air Propulsion Center

ADDRESS : P.O. Box 7176
Trenton, New Jersey 08628
USA

CONTACT : Resource Management Officer
Code RM

Phone 609-882-1414 Ext. 298 or 373

2 TEST CELLS

Designation	Engine	Altitude km	Mass Flow kg/s	Size H W L	Page
3 E	TJ/RJ	24.4	318	Diam 5.2 m x 9.1 m	6-13
2 E	TJ	24.4	195	Diam 4.4 m x 5.5 m	6-14
1 E	TJ	24.4	195	Diam 4.4 m x 5.5 m	6-14
3 W	TS	20.0	54.5	2.4 m x 2.4 m x 4.6 m	6-24
4 W	TS	20.0	54.5	Diam 3.0 m x 6.1 m	6-25
5 W	TS	20.0	54.5	2.9 m x 2.9 m x 5.2 m	6-26
6 W	TS	20.0	54.5	3.0 m x 3.0 m x 5.2 m	6-27
SLC 1 W	TJ/TS	Sea Level	159	4.3 m x 7.0 m x 17.1 m	7-13
SLC 2 W	TJ/TS	Sea Level	159	4.3 m x 7.0 m x 17.1 m	7-13
Var. Attitude Test Stand	TJ/TS	Sea Level	unlimited	Wing and Engine Center Line 1.5 ÷ 7.6 m above ground	7-3
Turntable Engine Stand	TJ/TS	Sea Level	unlimited		7-4

3 AIR SUPPLY AND EXHAUST FACILITIES

Ram air facility — Fixed exhaust diffuser (1 E/2 E)

Air heater

Air cooler — Test cell refrigeration } (1 W/2 W)

Exhaust gas cooler — Liquid air cooling system }

Vacuum exhauster

2 TEST CAPACITY OF ORGANISATIONS

1 ORGANISATION

NAME : Teledyne CAE/USAF Plant 27

ADDRESS : 1330 Laskey Road
Toledo, Ohio 43613
USA

CONTACT :

2 TEST CELLS

Designation	Engine	Altitude km	Mass Flow kg/s	Size H W L
TC-1	TJ	27.4	10(25) [1]	0.8 m x 1.2 m x 2.1 m
TC-2	TJ	27.4	10(25) [1]	0.8 m x 1.2 m x 2.1 m
Environmental Chamber	TJ	Sea Level		
Cell 41	TJ	Sea Level	27	

plus 8 additional sea level test cells not primarily used for research and development work.

[1] mass flow if altitude does not exceed 4.6 km

3 AIR SUPPLY AND EXHAUST FACILITIES

SUPPLY

Four compressors each delivering 5 kg/s, pressure ratio 1.33.
Compressors can be valved in series and parallel.

Two steam heaters each heating 5 kg/s up to 355/375 K
(Electrical heater (TC-1 and TC-2) 540 KW max.
discharge temperature 411 K)

One water cooler 5 kg/s to 267 K

Refrigeration system: total cooling capacity 530 kW
(stage discharge temperature are 277/310 K, 275 K, 241 K, and 219 K)

EXHAUST

Exhaust gas water cooler (TC-1 and TC-2) 11.7 MW

Fourteen vane type positive displacement vacuum pumps.

4 SUPPLEMENTARY INFORMATION

D.J. Fressie Teledyne CAE Small Gas Turbine Test Complex
ASME Paper 71-WA/GT-7

2 TEST CAPACITIES OF ORGANISATIONS

1 ORGANISATION

NAME and ADDRESS : United Technologies Corporation

1 Pratt & Whitney Aircraft Division
Government Products Division
Florida Research and Development Center
P.O. Box 2691
West Palm Beach, Florida 33402, USA

2 Pratt & Whitney Aircraft Division
Commercial Products Division
Andrew Willgoos Turbine Laboratory
East Hartford, Connecticut 06 108, USA

3 Chemical Systems Division
P.O. Box 458
Sunny vale, California, USA

2 TEST CELLS

Place	Designation	Engine	Altitude km	Mass Flow kg/s	Size	Page
FL	A - 1	TJ	simulated	114		6-37
FL	C - 4	TJ	simulated	55		6-38
FL	C - 5	TJ	simulated	55		6-38
FL	A - 2	TJ	Sea L.			
FL	A - 8	TJ	Sea L.			
FL	C -10	TJ	Sea L.			
CT	X -207	TJ	27.4	263	7 m	
CT	X -208	TJ	27.4	263	Diam 3.7 m x 10.4 m	
CT	X -210	TJ	27.4	227	7.8 m	
CT	X -209	TJ	27.4	147.6	Diam 3.7 m x 10.4 m	
CT	X -217	TJ	13.7	545	Diam 5.5 m x 10.7 m	6-32
CA	IRR-GTF	RJ	24.4	81.6		6-16

3. AIR SUPPLY AND EXHAUST FACILITIES

1. Florida Research and Development Center
   no information available

2. Andrew Willgoos Turbine Laboratory

   Power Supply:
   - o Six naval cruiser-type boilers producing 503 t/h steam at 3 MPa and 666 K i.e. about 102 MW.

     Twenty-one steam turbines in the range of 4.4 ÷ 29.4 MW
   - o Three P & W industrial gas turbines (type FT4A-8LF) each rated at 21 MW (3600 rpm) for 26.7°C - day, particularly used for driving six exhausters.

   Ram Air Facility:
   - o Thirteen air compressors (five different types of machines) to be operated in various combinations and delivering e. g. 265 kg/s at 304 kPa
     60 kg/s at 847 kPa
   - o Air refrigeration system T ≥ 216 K
   - o Air heating system e.g. 265 kg/s up to 630 K

   Exhaust:

   Twelve centrifugal exhausters (32.3 m^3/s each) - eight exhausters may be used as compressors also.

   Six axial exhausters (133.6 m^3/s each).

3. Chemical System Division

   Ram Air Supply:
   - o Compressed air storage 13.600 kg air at 16.9 MPa
   - o Vitiated air heater
   - o Oxygen addition and control

   Exhaust System
   - o Steam accumulator (34.000 kg of steam at a rate of 34 kg/s)
   - o Steam driven ejector

4. SUPPLEMENTARY INFORMATION

G. P. Adamson: Jet Engine Test Facilities: Laboratories for Tomorrow's Engines
ASME Paper 71-WA/GT-12

T. D. Myers
G. Stromberg
Ground Test Facility for Integral Rocket Ramjet Engines
AIAA/SAE 14th Joint Propulsion Conference, Paper No. 78-934
Las Vegas, Nev., July 25 - 27, 1978

3 LIST OF ALTITUDE TEST CELLS

ENGINE TJ	RJ	TS	ALTITUDE KM	MACH RANGE	MAX.MASS FLOW RATE KG/S	TEST FACILITY DESIGNATION	PAGE	ORGANISATION NAME	PAGE
x	x		52	0.8-8.2	363	TC-8		MAR	2-26
x	x		13.7-47.2	1.5-4.75		PWT 16 S	6-1	AEDC	2-22
	x		45.7	1 -10	68	TC-1		JHU-APL	2-25
	x		45.7	1 -10	68	TC-2		JHU-APL	2-25
	x		45.7	1 -10	68	TC-3		JHU-APL	2-25
	x		45.7	1 -10	68	TC-4		JHU-APL	2-25
x	x		30.5	0 - 3.8	1,250	ASTF C 2	6-2	AEDC	2-22
	x		30.5	0 - 5.6	863	APTU	6-3	AEDC	2-22
x	x		30.5	0 - 3.8	660	ASTF C 1	6-2	AEDC	2-22
x	x		30.0	0 - 3.5	270	ATF Cell 4	6-4	NGTE	2-16
x	x		30.0	0 - 3.5	180	ATF Cell 1	6-5	NGTE	2-16
x	x		27.5	0.2-1.5		PWT 16 T	6-6	AEDC	2-22
x			27.4	0 - 3.0	263	X-207		P & W - AW	2-30
x			27.4	0 - 3.0	263	X-208		P & W - AW	2-30
x			27.4	0 - 3.0	227	X-210		P & W - AW	2-30
x	x		27.4	0 - 4.2	182	TP 131 A	6-7	RR-BR	2-19
x			27.4	0 - 3.0	147.6	X-209		P & W - AW	2-30
x			27.4	0 - 2.0	10	TC-1		TE-CAE	2-29
x			27.4	0 - 2.0	10	TC-2		TE-CAE	2-29
x	x		24.4	0 - 3.3	636	J-1	6-8	AEDC	2-22
x	x		24.4	0 - 3.3	636	J-2	6-9	AEDC	2-22
x			24.4	0 - 3.0	454	TC-43		GE	2-23
x	x		24.4	0 - 3.0	363	T-1	6-10	AEDC	2-22
x	x	x	24.4	0 - 3.0	363	T-2	6-11	AEDC	2-22
x	x		24.4	0 - 3.0	363	T-4	6-12	AEDC	2-22
x	x		24.4	0 - 3.0	318	3 E	6-13	NAPC	2-28
x			24.4	0 - 2.4	195	2 E	6-14	NAPC	2-28
x			24.4	0 - 2.4	195	1 E	6-14	NAPC	2-28
x	x		24.4	0.8-5.0	182	TC-2		MAR	2-26
x			24.4	0 - 3.0	182	TC-44		GE	2-23
x			24.4	0 - 3.0	170	T-6	6-15	AEDC	2-22
	x		24.4		81.6	IRR-GTF	6-16	UTRC-SD	2-30
x	x		24.4	0 - 1.5	41	T-5	6-17	AEDC	2-22
x			21.3	0 - 4.0	340	PSL-4	6-18	NASA-LE	2-27
x			21.3	0 - 3.0	340	PSL-3	6-18	NASA-LE	2-27
x		x	21.3	0 - 2.5	272	ATF Cell 1	6-19	RR-DE	2-19
x			21.3	0 - 2.5	272	ATF Cell 2	6-19	RR-DE	2-19
x	x		21.3	0 - 3.0	204	PSL-1	6-20	NASA-LE	2-27
x	x		21.3	0 - 3.0	204	PSL-2	6-20	NASA-LE	2-27
x			20.0	0 - 4.0	375	R 5	6-21	CEPr	2-7
x			20.0	0 - 2.4	200	R 3	6-22	CEPr	2-7
x			20.0	0 - 2.4	200	R 4	6-22	CEPr	2-7
x	x	x	20.0	0 - 2.2	70	HPT	6-23	US-ILA	2-11
		x	20.0	0 - 1.0	54.5	871-2		DDAD	2-24
		x	20.0		54.5	3 W	6-24	NAPC	2-28
		x	20.0		54.5	4 W	6-25	NAPC	2-28
		x	20.0		54.5	5 W	6-26	NAPC	2-28
		x	20.0		54.5	6 W	6-27	NAPC	2-28

3 LIST OF ALTITUDE TEST CELLS

ENGINE TJ	RJ	TS	ALTITUDE KM	MACH RANGE	MAX.MASS FLOW RATE KG/S	TEST FACILITY DESIGNATION	PAGE	ORGANISATION NAME	PAGE
x	x		19.0	0 - 3.5	270	ATF Cell 3	6-28	NGTE	2-16
x			18.0	subsonic	630	ATF Cell 3 W	6-29	NGTE	2-16
x	x		17.0	0 - 2.5	180	ATF Cell 2	6-30	NGTE	2-16
x	x		16.8		109	Ramjet		AFAPL	2-20
x			15.2	0 - 1.0	190	881		DDAD	2-24
x			15.2	0 - 1.5	109	TC 21		AFAPL	2-20
x			15.2	0 - 1.5	109	TC 24		AFAPL	2-20
x	x	x	15.0	0 - 2.0	100	S 1	6-31	CEPr	2- 7
x			13.7	0 - 1.0	545	X-217	6-32	P & W - AW	2-30
x		x	13.7	0 - 1.0	45.4	873		DDAD	2-24
x		x	13.7		5.4	ALT.FAC.	6-33	NRC	2- 3
x		(x)	11.0 (5.6)	0 - 1.0	55	C 1	6-34	CEPr	2- 7
x		x	10.0	0.1-1.0		R 2	6-35	CEPr	2- 7
x		x	10.0	0.1-1.0		R 6	6-36	CEPr	2- 7
		x	7.6	$\prec$1.0	2.5	885		DDAD	2-24
	x					TC-7		MAR	2-26
x						A-1	6-37	P & W - FL	2-30
x						C-4	6-38	P & W - FL	2-30
x						C-5	6-38	P & W - FL	2-30

4 LIST OF SEA LEVEL TEST FACILITIES

ENGINE			MASS FLOW	THRUST/ SHAFT P.	SPECIAL CAPABILITY	TEST FACILITY		ORGANISATION	
TJ	RJ	TS	KG/S	KN/KW	SECTION	DESIGNATION	PAGE	NAME	PAGE
x			Unlimited	310 kN	5.3/5.5/5.12	TB No 9	7-1	RR-HU	2-19
x			Unlimited	222 kN	5.1/5.3/5.8	METS A+B	7-2	RR-BR	2-19
x		x	Unlimited	222 kN	5.4/5.8/5.10	Var.Attitude Stand	7-3	NAPC	2-28
x		x	Unlimited	222 kN	5.3/5.12	Turntable Engine Stand	7-4	NAPC	2-28
x		x	Unlimited	180 kN	5.2	TX	7-5	CEPr	2-7
x		x	Unlimited	2x90kN	5.2/5.5/5.10	TB No 5	7-6	RR-HU	2-19
x		x	Unlimited	90(45) [1] kN	5.3/5.5	TB No 7	7-7	RR-HU	2-19
x			Unlimited			ISite No 3		SNECMA	2-8
x			Unlimited			I " No 5		SNECMA	2-8
x				445 kN	5.7	A-8	7-8	P&W-FL	2-30
x				334 kN	5.8	C-10		P&W-FL	2-30
x		x	~1300	20 kN Lift 10 kN Drag		Propulsion Tunnel		NRC	2-3
x			1200	250 kN		T 1		CEPr	2-7
x			1045	267 kN		SLETF		AFAPL	2-20
x			1000	310 kN	5.8	TB No 48		RR-DE	2-19
x			1000	310 kN	5.8	TB No 49		RR-DE	2-19
x			907	310 kN	5.2/5.5	TB No 10		RR-HU	2-19
x				267 kN		A-2		P&W-FL	2-30
x				180 kN		No 3 TB		RR-CA	2-5
x			536	178 kN	5.8	TP 105	7-10	RR-BR	2-19
x			536	178 kN	5.8	TP 137	7-10	RR-BR	2-19
x			500			W 1 C 7		SNECMA	2-8
x			500			W 1 H 8		SNECMA	2-8
x			454	98 kN	5.11	TP 107		RR-BR	2-19
x			400			W 2 C 7		SNECMA	2-8
x			400	100 kN		Cell No 6		FIAT	2-14
x			304	98 kN	5.11	TP 103		RR-BR	2-19
x			304	98 kN	5.11	TP 104		RR-BR	2-19
x			272	222 kN	5.7	TP 140		RR-BR	2-19
x			272	222 kN	5.7	TP 141		RR-BR	2-19
x				222 kN		5-11	7-11	P&W-AC	2-4
x			250 [2]	80 kN		ETB No 1		MTU	2-10
x			250 [2]	80 kN		ETB No 2		MTU	2-10
x			227	22 kN		1-16 / 1-17		P&W-AC	2-4
x		x	204	133 kN		TB No 8	7-12	RR-HU	2-19
x		x	200	190 kN		Glen Test House		NGTE	2-16
x			200			W 11 H 7		SNECMA	2-8
x			180	130 kN	5.11	TB No 41		RR-DE	2-19
x			180	130 kN	5.11	TB No 42		RR-DE	2-19
x			180	130 kN	5.11	TB No 43		RR-DE	2-19
x			180	130 kN	5.11	TB No 44		RR-DE	2-19
x			180	90 kN	5.8	TB No 2		RR-HU	2-19
x			170	222 kN	5.11	TP 108		RR-BR	2-19
x		x	159	133 kN	5.1/5.9	SLC 1 W	7-13	NAPC	2-28
x		x	159	133 kN	5.1/5.9	SLC 2 W	7-13	NAPC	2-28
x			136	135 kN		No 5 TC		NRC	2-3

1) Reverse thrust 2) Exhaust 700

4 LIST OF SEA LEVEL TEST FACILITIES

ENGINE			MASS FLOW	THRUST/ SHAFT-P.	SPECIAL CAPABILITY	TEST FACILITY		ORGANISATION	
TJ	RJ	TS	KG/S	KN/KW	SECTION	DESIGNATION	PAGE	NAME	PAGE
x				111 kN				AIRes.	2-21
x				111 kN				AIRes.	2-21
x			100	80 kN	5.2/5.4	Field	7-14	MTU	2-10
x			100			W 9 H 7		SNECMA	2-8
x			100			W 10 H 7		SNECMA	2-8
x			100			W 12 H 7		SNECMA	2-8
x			100			W 7 H 5		SNECMA	2-8
x			100			W 8 H 5		SNECMA	2-8
	x		90	10 kN	5.4	VMK	7-15	DFVLR	2-9
x				67 kN		No 2 TB		RR-CA	2-5
x				67 kN		Honiley		LUCAS	2-15
x			77	36 kN	5.12	TP 131 E		RR-BR	2-19
x			77		5.12	TP 125		RR-BR	2-19
x			27			Cell 41		TE-CAE	2-29
x					5.9	Env. Chamber		TE-CAE	2-29
x			15.2			No 1 TC		NRC	2-3
x			15.0		5.1	No 4 TC	7-16	NRC	2-3
x			5.0			ETB No 9		MTU	2-10
x		x			5.9	1-11 A	7-17	P&W-AC	2-4
x		x		2 kN 2000 kW	5.4	H 9	7-18	CEPr	2-7
		x		29 MW		Gas Turbine Test Fac.		WE-CA	2-6
		x		8950 kW		2-3		P&W-AC	2-4
		x	1800	6600 kW	5.6	Hangar H	7-19	RR-DE	2-19
		x	26	6600 kW	5.12	TB No 16		RR-DE	2-19
		x	26	6600 kW	5.12	TB No 18		RR-DE	2-19
		x		3900 kW		No 1 TB		RR-CA	2-5
	5	x		60-2575 kW				NPT	2-17
		x		2200 kW	5.6	T 64	7-20	RR-CA	2-5
		x		1840 kW		2-1		P&W-AC	2-4
		x		1840 kW		1-5		P&W-AC	2-4
		x		1840 kW		TB No 16	7-21	RR-HA	2-19
		x	8.2	1765 kW		1-2		P&W-AC	2-4
		x	5.0	1470 kW		No 2 TC		NRC	2-3
		x		1470 kW	5.7	TB No 15	7-22	RR-HA	2-19
		x		1470	5.12	TB No 19		RR-HA	2-19
		x		1100 kW	5.7	TB No 12	7-23	RR-HA	2-19
		x		1100 kW	5.7	TB No 13/13A	7-23	RR-HA	2-19
		x		1100 kW		TB No 20		RR-HA	2-19
		x	385	956 kW	5.6	1-1	7-24	P&W-AC	2-4
		x	385	956 kW	5.6	1-6	7-24	P&W-AC	2-4
		x	385	956 kW	5.6	1-18	7-24	P&W-AC	2-4
		x	385	956 kW	5.6	2-4	7-24	P&W-AC	2-4
		x		956 kW		Dynamometer T.B.		AR	2-12
		x		735 kW	5.12	TB No 11		RR-HA	2-19
		x		662 kW	5.6	TB No 21	7-25	RR-HA	2-19
		x	2.5[3)]	660 kW		ETB No 3		MTU	2-10

3) Exhaust 5.0

4 LIST OF SEA LEVEL TEST FACILITIES

ENGINE			MASS FLOW	THRUST/ SHAFT-P.	SPECIAL CAPABILITY	TEST FACILITY		ORGANISATION	
TJ	RJ	TS	KG/S	KN/KW	SECTION	DESIGNATION	PAGE	NAME	PAGE
		x	3	660 kW		ETB No 6		MTU	2-10
		x	2.5[4)]	500 kW				CC-AMPD	2-2
		x		400 kW		ETB No 4		MTU	2-10
		x		309 kW				EM	2-13
		x	4.5	220 kW	5.1/5.2/5.3 5.8/5.12	PASTF	7-26	PL	2-18
		x	2	180 kW		ETB No 7		MTU	2-10
		x						CU-GTL	2-1
		x			5.6	Hangar TB	7-27	AR	2-12
		x				Cell No 9		FIAT	2-14

4) Exhaust 6.0

5 LIST OF TEST FACILITIES WITH SPECIAL CAPABILITIES

TYPE OF ENGINE	ALTITUDE KM	MASS FLOW KG/S	THRUST/ SHAFT-P. kN/kW	TEST FACILITY DESIGNATION	PAGE	ORGANISATION NAME	PAGE
5.1 I C I N G							
TJ/RJ	24.4	636		J-1	6-8	AEDC	2-22
TJ/RJ	24.4	318	222 kN	3-E	6-13	NAPC	2-28
TJ	24.4	195	133 kN	2-E	6-14	NAPC	2-28
TJ	24.4	195	133 kN	1-E	6-14	NAPC	2-28
TJ	19.0	270	220 kN	ATF Cell 3	6-28	NGTE	2-16
TJ	18.0	630	220 kN	ATF Cell 3W	6-29	NGTE	2-16
TJ/TS	10.0			R 2	6-35	CEPr	2-7
TJ	Sea L.	Unlimited	222 kN	METS A+B	7-2	RR-BR	2-19
TJ/TS	Sea L.	159	133 kN	SLC 1 W	7-13	NAPC	2-28
TJ/TS	Sea L.	159	133 kN	SLC 2 W	7-13	NAPC	2-28
TJ	Sea L.	15		No 4 TC	7-16	NRC	2-3
TS	Sea L.	4.5	220 kW	PASTF	7-26	PL	2-18
5.2 F O R E I G N O B J E C T D A M A G E							
TJ	Sea L.	Unlimited	310 kN	TB No 9	7-1	RR-HU	2-19
TJ	Sea L.	Unlimited	222 kN	METS A+B	7-2	RR-BR	2-19
TJ/TS	Sea L.	Unlimited	180 kN	Tx	7-5	CEPr	2-7
TJ/TS	Sea L.	Unlimited	2x90 kN	TB No 5	7-6	RR-HU	2-19
TJ	Sea L.	907	310 kN	TB No 10	7-9	RR-HU	2-19
TJ	Sea L.		222 kN	5-11	7-11	P & W-AC	2-4
TJ	Sea L.	100	80 kN	Field	7-14	MTU	2-10
TS	Sea L.	4.5	220 kW	PASTF	7-26	PL	2-18
5.3 N O I S E							
TJ	Sea L.	Unlimited	310 kN	TB No 9	7-1	RR-HU	2-19
TJ	Sea L.	Unlimited	222 kN	METS A+B	7-2	RR-BR	2-19
TJ/TS	Sea L.	Unlimited	222 kN	Turntable Eng.Stand	7-4	NAPC	2-28
TJ/TS	Sea L.	Unlimited	90 kN	TB No 7	7-7	RR-HU	2-19
TS	Sea L.	4.5	220 kW	PASTF	7-26	PL	2-18
5.4 A T T I T U D E (ENGINE INCIDENCE AND YAW VARIATION)							
TJ	30.0	720	220 kN	ATF Cell 4	6-4	NGTE	2-16
TJ/TS	Sea L.	Unlimited	222 kN	Var.Attitude Stand	7-3	NAPC	2-28
TJ	Sea L.	100	80 kN	Field	7-14	MTU	2-10
RJ	Sea L.	90	10 kN	VMK	7-15	DFVLR	2-9
TJ/TS	Sea L.		2/2000	H 9	7-18	CEPr	2-7

5 LIST OF TEST FACILITIES WITH SPECIAL CAPABILITIES

TYPE OF ENGINE	ALTITUDE KM	MASS FLOW KG/S	THRUST/ SHAFT-P. KN/KW	TEST FACILITY DESIGNATION	PAGE	ORGANISATION NAME	PAGE
5.5 INTAKE COMPATIBILITY/CROSS WIND							
TJ	Sea L.	Unlimited	310 kN	TB No 9	7-1	RR-HU	2-19
TJ/TS	Sea L.	Unlimited	2 x 90 kN	TB No 5	7-6	RR-HU	2-19
TJ/TS	Sea L.	Unlimited	90 kN	TB No 7	7-7	RR-HU	2-19
TJ	Sea L.	907	310 kN	TB No 10	7-9	RR-HU	2-19
5.6 TS-ENGINE WITH PROPELLER							
TS	Sea L.	1800	6600 kW	Hangar H	7-19	RR-DE	2-19
TS	Sea L.		2200 kW	T 64	7-20	RR-CA	2-5
TS	Sea L.	385	956 kW	1-1	7-24	P&W-AC	2-4
TS	Sea L.	385	956 kW	1-6	7-24	P&W-AC	2-4
TS	Sea L.	385	956 kW	1-18	7-24	P&W-AC	2-4
TS	Sea L.	385	956 kW	2-4	7-24	P&W-AC	2-4
TS	Sea L.		662 kW	TB No 21	7-25	RR-HA	2-19
TS	Sea L.			Hangar TB	7-27	AR	2-12
5.7 PREHEATED AIR/HEATED INLET							
TJ	Sea L.		445 kN	A-8	7-8	P&W-FL	2-30
TJ	Sea L.	272	222 kN	TP 140		RR-BR	2-19
TJ	Sea L.	272	222 kN	TP 141		RR-BB	2-19
TS	Sea L.		1470 kW	TB No 15	7-22	RR-HA	2-19
TS	Sea L.		1100 kW	TB No 12	7-23	RR-HA	2-19
TS	Sea L.		1100 kW	TB No 13	7-23	RR-HA	2-19
TS	Sea L.		1100 kW	TB No 13 A	7-23	RR-HA	2-19
5.8 VECTORED AND REVERSE THRUST/JET DEFLECTION							
TJ/TS	Sea L.	Unlimited	222 kN	Var.Attitude Stand	7-3	NAPC	2-28
TJ	Sea L.	1000	310 kN	TB No 48		RR-DE	2-19
TJ	Sea L.	1000	310 kN	TB No 49		RR-DE	2-19
TJ	Sea L.		334 kN	C-10		P&W-FL	2-30
TJ	Sea L.	536	178 kN	TP 105	7-10	RR-BR	2-19
TJ	Sea L.	536	178 kN	TP 137	7-10	RR-BR	2-19
TJ	Sea L.	180	90 kN	TB No 2		RR-HU	2-19
TS	Sea L.	4.5	220 kW	PASTF	7-26	PL	2-18
5.9 COLD START							
TJ/TS	Sea L.	204	133 kN	TB No 8	7-12	RR-HU	2-19
TJ/TS	Sea L.	159	133 kN	SLC 1 W[1)]	7-13	NAPC	2-28
TJ/TS	Sea L.	159	133 kN	SLC 2 W[1)]	7-13	NAPC	2-28
TJ/TS	Sea L.			1-11 A	7-17	P&W-AC	2-4
TJ	Sea L.			Env.Chamber		TE-CAE	2-29

5 LIST OF TEST FACILITIES WITH SPECIAL CAPABILITIES

TYPE OF ENGINE	ALTITUDE KM	MASS FLOW KG/S	THRUST/ SHAFT-P. KN/KW	TEST FACILITY DESIGNATION	PAGE	ORGANISATION NAME	PAGE
5.10 TWIN-ENGINE							
TJ/TS	Sea L.	Unlimited	222 kN	Var.Attitude Stand	7-3	NAPC	2-28
TJ/TS	Sea L.	Unlimited	2x90 kN	TB No 5	7-6	RR-HU	2-19
TS	Sea L.		1840 kW	TB No 16	7-21	RR-HA	2-19
5.11 REHEAT							
TJ	Sea L.	454	98 kN	TP 107		RR-BR	2-19
TJ	Sea L.	304	98 kN	TP 103		RR-BR	2-19
TJ	Sea L.	304	98 kN	TP 104		RR-BR	2-19
TJ	Sea L.	180	130 kN	TB No 41		RR-DE	2-19
TJ	Sea L.	180	130 kN	TB No 42		RR-DE	2-19
TJ	Sea L.	180	130 kN	TB No 43		RR-DE	2-19
TJ	Sea L.	180	130 kN	TB No 44		RR-DE	2-19
TJ	Sea L.	170	222 kN	TP 108		RR-BR	2-19
5.12 OTHER SPEC. CAP.							
X - RAY							
TJ	Sea L.	Unlimited	310 kN	TB No 9	7-1	RR-HU	2-19
INFRA-RED SIGNATURE							
TJ/TS	Sea L.	Unlimited	222 kN	Turntable Eng.Stand	7-4	NAPC	2-28
VIBRATION							
TS	Sea L.	4.5	220 kW	PASTF	7-26	PL	2-18
SPOOL TESTING							
TJ	Sea L.	77	36 kN	TP 131 E		RR-BR	2-19
TJ	Sea L.	77		TP 125		RR-BB	2-19
DYNAMOMETER							
TS	Sea L.	26	6600 kW	TB No 16		RR-DE	2-19
TS	Sea L.	26	6600 kW	TB No 18		RR-DE	2-19
TS	Sea L.		1470 kW	TB No 19		RR-HA	2-19
TS	Sea L.		735 kW	TB No 11		RR-HA	2-19

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 13.7 - 47.2 km

FLIGHT MACH N° 1.5 - 4.75

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
AEDC Arnold Engineering Development Center	Arnold Air Force Station Tennessee USA	PWT 16 S

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet (closed loop wind tunnel)	Accepts engines with cowling full scale and in missiles

SIZE : WIDTH 4.88 m HEIGHT 4.88 m DIAM LENGTH 12.20 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW kg/s

PRESSURE kPa 2.9 - 23.4 (operating range of stagnation press.)

TEMPERATURE K 322 - 600 (operating range of stagnation temp.)

Mach-No	- Flight Height Range
1.5	13.7 - 22 km
2.4	20.7 - 33.5 km
3.4	30.5 - 45.7 km
4.75	41.1 - 47.2 km

TRANSIENTS

Mach No	1.5 - 2.4	0.05 Mach/minute
Mach No	2.4 - 4.75*	0.14 Mach/minute

*changes beyond 4.5 require three five minutes tape changes at M = 3.7

The PWT comprises two separate Windtunnels 16 T (transonic) and 16 S (supersonic). Both tunnels employ the same set of two induction (25 and 18 MW) and two synchronous motors (each 61 MW) for driving their separate compressor sets. They are primarily designed for various aerodynamic tests but both have systems to remove engine exhaust gases from the tunnel and replace with clean air. Typical testing of air-breathing engines includes the following:

1) engine-inlet matching involving changes in pressure recovery and distribution with model altitude and engine power
2) propulsion nozzle and afterbody characteristics
3) variable geometry performance in inlet and nozzles
4) control systems interactions and response characteristics for complete propulsion systems
5) heat-transfer studies of cooling systems including auxiliary inlets and of internal cooling effectiveness

The aim is usually a combined systems test i.e. propulsion and aerodynamics, and not engine performance. Therefor correct simulation of flight conditions is dispensable and some mismatch of stagnation temperature is tolerated.

Both tunnels are equipped with flexible wall Laval-type nozzles leading into 4.88 m x 4.88 m quadratic test sections of up to 12 m length. Test section and +)

PUBLICATION ETC AEDC Test Facilities Handbook, June 1979

+) Continued on Page 8-2, Appendix II

3 CONTACT :

Arnold Engineering Development Center
AEDC/DOX
Arnold Air Force Station
Tennessee 37389
USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 30.5 km

FLIGHT MACH N° - 3.8

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
AEDC Arnold Engineering Development Center	Arnold Air Force Station Tennessee USA	ASTF C 1 and ASTF C 2

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet	
Ram-Jet	Direct Connect	

SIZE : WIDTH HEIGHT DIAM 8.53 m LENGTH 25.9 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY		C 2	C 1 and C 2			
MASS FLOW	kg/s	1250 (with atmospheric inbleed)	660		500	
PRESSURE	kPa		276		896	
TEMPERATURE	K	200 - 822				
EXHAUST		C 1 C 2				
MASS FLOW	kg/s	1250 660	1135	almost linearly	136	
PRESSURE	kPa	70	31	decreasing to	4.1	
TEMPERATURE	K	as from engine delivered				

TRANSIENTS Full flight environment and engine power transients

Mass Flow Rate 227 kg/s^2

Inlet Pressure 2.76 kPa/s

Inlet Temperature 2.2 K/s

Both cells are part of an open-circuit facility designed primarily for testing air-breathing engine propulsion systems in an optimised free-jet test mode. It is possible to produce transient rate-of-change necessary to follow both flight environment and engine power transients. Three nozzles are available permitting test up to Mach.7 with jet cross section of 9.3 m^2, up to 1.0 with 5.6 m^2 and up to 3.8 with 4.2 m^2

MEASURING EQUIPMENT

- 1700 "static" measurements (typically < 1 kHz) including
  600 pneumatic multiplex
  1020 electrical multiplex
- 226 "dynamic" measurements up to 20 kHz
  including 24 channels up to 50 kHz
  12 channels up to 100 kHz

DATA ACQUISITION AND PROCESSING Mass Data Storage Facility (MDSF) and Executive Data Processing System (EDPS). EDPS accomplishes major performance calculations in real time with testing activities. An extensive interactive display system, both alpha-numeric and graphic terminals, is provided.

PUBLICATION ETC

J.G. MITCHELL
The Aero-Propulsion Systems Test Facility
AIAA Paper No 72-1034, 1972

3 CONTACT :

Arnold Engineering Development Center
AEDC/DOX
Arnold Air Force Station
Tennessee 37389, USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 30.5 km.

FLIGHT MACH N° up to 5.6

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
AEDC Arnold Engineering Development Center	Arnold Air Force Station Tennessee USA	APTU

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Ram-Jet	Free Jet Direct Connect	

SIZE : WIDTH — HEIGHT Test Section 1.22 m, Test Cell DIAM 4.88 m — LENGTH 12.8 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	863	
PRESSURE	kPa	2070	(stagnation)
TEMPERATURE	K	1111	(stagnation)

EXHAUST

MASS FLOW	kg/s
PRESSURE	kPa
TEMPERATURE	K

TRANSIENTS

The APTU is an intermittent (blow-down) -type true temperature test facility for testing air-breathing propulsion systems, aerodynamic systems and materials while simulating actual flight conditions at supersonic velocities. There is a diffusor and an annular jet pump installed but no connection is available to the central exhaust system.
Approximately 204 000 kg of compressed air may be stored at 27.6 MPa in an array of vessels with a total volume of 630 m^3. The valving arrangement permits the division of the total volume into two independant storage systems one of which feeds the air through the stored energy heater (max matrix temperature 1366 K, max massflowrate 116 kg/s). The desired test conditions are produced by mixing both the cold and the heated air stream. In addition a vitiated air heater shall be available from 1980.

PUBLICATION ETC AEDC Test Facilities Handbook, June 1979

3 CONTACT :

Arnold Engineering Development Center
AEDC/DOX
Arnold Air Force Station
Tennessee 37389
USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 30,0 km

FLIGHT MACH N° - 3.5

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NGTE National Gas Turbine Establishment	Pyestock Farnborough UK	Altitude Test Facility Cell 4

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet Ram-Jet	Free Jet	Attitude (Variation of intake incidence and yaw)

SIZE : WIDTH HEIGHT DIAM 9 m LENGTH 21 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	270 max.
PRESSURE	kPa	abs 300 max.
TEMPERATURE	K	ambient to 740

EXHAUST

MASS FLOW	kg/s	270
PRESSURE	kPa	abs 35 (Min pres 11.3)
TEMPERATURE	K	2000

TRANSIENTS: Full engine transients plus flight transients
Mach No 0.02/s; pitch 10 °/s; yaw 5 °/s

REMARKS: Cell 4 is a large free-jet supersonic test cell with a variable Mach number blowing nozzle and variation of incidence and/or yaw while running. It was designed to test engines of about 70 kg/s (150 lb/s) sea-level static flow over a range of Mach number from 1.5 to 3.5. The size of the blowing nozzle has since been doubled to 2.3 m^2 (25 sq ft) to enable tests of a Concorde intake and Olympus 593 engine to be carried out over a Mach number range from about 1.7 to 2.3. It has recently been used for free-jet testing at subsonic speeds.
Operating such large plant is costly and a meticulous approach is essential to ensure that the maximum amount of information is obtained in the shortest possible time. For this reason the test instrumentation is directly connected to a computer and the data processed on-line, giving the test controller immediate information on all the essential parameters, both measured and computed, whilst the test is in progress.
Cell is not at present in use but is being held on a care & maintenance basis.

MEASURING EQUIPMENT: No thrust measurement capability
Standard facility for 200 individual temperatures and 300 individual pressures plus shaft speed and fuel flow. 40 transient pressures can be continuously recorded on magnetic tape.

DATA ACQUISITION AND PROCESSING: On-line processing (at data processing center) and display.

PUBLICATION ETC: Journal RAeS, Vol 74, pp 205-212 (1970)

3 CONTACT :

Director
NGTE
Pyestock
Farnborough GU14 OLS
Hants
UK

Phone Farnborough 44411
Telex 858231

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) ÷ 30 km

FLIGHT MACH N° ÷ 3.5

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NGTE National Gas Turbine Establishment	Pyestock Farnborough UK	Altitude Test Facility Cell 1

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Ram-Jet	Free Jet	
Turbo-Jet		

SIZE : WIDTH HEIGHT DIAM 3.7 m LENGTH 37 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	180 max
PRESSURE	kPa abs	910 max
TEMPERATURE	K	ambient to 490 max

EXHAUST

MASS FLOW	kg/s	77
PRESSURE	kPa abs	50 (min pressure 14)
TEMPERATURE	K	2000

TRANSIENTS: Full engine transients

REMARKS: Cell 1 was originally designed for the free-jet testing of jet engines, also used for testing model air intakes for supersonic aircraft and other altitude tests.

MEASURING EQUIPMENT: Standard facilities for 200 individual temperatures and 300 individual pressures plus shaft speed and fuel flow.

DATE ACQUISITION AND PROCESSING: On-line processing (at data processing center) and display

PUBLICATION ETC: General description and background
Engineering June 14, 21, 28 (1957)

3 CONTACT :

Director
NGTE
Pyestock
Farnborough GU14 OLS
Hants
UK

Phone Farnborough 44411
Telex 858231

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 27.5 km

FLIGHT MACH N° 0.2 - 1.5

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
AEDC Arnold Engineering Development Center	Arnold Air Force Station Tennessee USA	PWT 16 T

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet Ram-Jet	Free Jet (closed loop wind tunnel)	Accepts engines with cowlings full scale and in missiles

SIZE : WIDTH 4.88 m HEIGHT 4.88 m DIAM LENGTH 12.2 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s		
PRESSURE	kPa	1.75 - 58.4	(operating range of stagnation pressure)
TEMPERATURE	K	324 - 380	(operating range of stagnation temperature)

EXHAUST		Mach-No	- Flight Height Range
MASS FLOW	kg/s	0.2	0 - 20 kkm
PRESSURE	kPa	0.8	0 - 24 km
TEMPERATURE	K	1.5	9.8 - 27.5 km

TRANSIENTS Mach-No 1.0 ÷ 1.6 50 discrete steps within 11 minutes

The PWT comprises two separate Windtunnels 16 T (transonic) and 16 S (supersonic). Both tunnels employ the same set of two induction (25 and 18 MW) and two synchronous motors (61 MW each) for driving their separate compressor sets. They are primarily designed for various aerodynamic tests but both have systems to remove engine exhaust gases from the tunnel and replace with clean air. Typical testing of air-breathing engines includes the following:

1) engine-inlet matching involving changes in pressure recovery and distribution with model altitude and engine power
2) propulsion nozzle and afterbody characteristics
3) variable geometry performance in inlet and nozzles
4) control systems interactions and response characteristics for complete propulsion systems
5) heat-transfer studies of cooling systems including auxiliary inlets and of internal cooling effectiveness

The aim is usually a combined systems test i.e. propulsion and aerodynamics, and not engine performance. Therefor correct simulation of flight conditions is dispensable and some mismatch of stagnation temperature is tolerated.

Both tunnels are equipped with flexible wall Laval-type nozzles leading into 4.88 m x 4.88 m quadrate test sections of up to 12 m length. Test section and supporting structure is an entire unit (test section cart) and removable from tunnel. Five carts are available (two 12m, three 6 m long) with different support systems (vertical strut pitching system; vertical pitch table; sting; special).+)

PUBLICATION ETC AEDC Test Facilities Handbook

+) Continued on page 8 - 2, Appendix II

3 CONTACT :

Arnold Engineering Development Center
AEDC/DOX
Arnold Air Force Station
Tennessee 37389
USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 27.4 km

FLIGHT MACH N° - 4.2

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls-Royce Ltd Aero Division Bristol	Gipsy Patch North Bristol U.K.	TP 131 A

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet Ram-Jet	Free Jet Connected Duct	Allows also testing of small turbine engines, turbojet combustors, HP single spool units, and intake models

SIZE : WIDTH HEIGHT DIAM 3.05 m LENGTH 24.4 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	77.2	295 (not continuously; HP-storage of 32700 kg air at max 24.8 MPa)
PRESSURE	kPa	1138	
TEMPERATURE	K	≈ 723	(without vitiation)

EXHAUST

MASS FLOW	kg/s	182	(maximum ejector mass flow)
PRESSURE	kPa	10.3	
TEMPERATURE	K	623	

TRANSIENTS: Missile boost simulation; spool engine acceleration/deceleration simulation

REMARKS: The test cell in simple terms is a 10 feet diameter x 80 feet long pressure vessel (test cell) containing the unit on test which is fed with air at the correct temperature and pressure. Exhaust products and surplus air are removed from the test cell by steam driven ejectors. Control of atmospheric air in-bleed to the test cell determines the pressure within the cell and hence the altitude simulation. Subsidiary ejectors within the cell provide control of intake conditions under supersonic operation and additional altitude capability when required.
Control of the plant is achieved by feed-back loop systems and recently a computer has been installed to function in conjunction with systems to provide transient control. Systems are also available for the control of fuels, oil and water.

MEASURING EQUIPMENT: D.C.U.-system comprising 640 channels total.
(50 Pt/PtRh / 200 Ch/Al thermocouples; 30 individual pressure channels, 7 x 48 port scanivalves; 2 thrust channels, 12 fuel flow channels, 5 F/Dc channels; 5 dialled in const.)

DATA ACQUISITION AND PROCESSING: The data collection unit (D.C.U.) is linked to the central computer which provides on-line computed information in the test bed control room.

PUBLICATION ETC

3 CONTACT :

Mr. R.F. Jeffery, Assistant Chief Engineer
Test Engineers Department
Gipsy Patch North
Rolls-Royce Ltd, Aero Division Bristol
P.O. Box 3
Filton, Bristol, U.K.

Phone
Bristol
693871
Ext 384

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 24.4 km

FLIGHT MACH N° - 3.3

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
AEDC Arnold Engineering Development Center	Arnold Air Force Station Tennessee USA	Propulsion Development Test Cell J 1

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet	Icing Test
Ram-Jet	Direct Connect	

SIZE : WIDTH HEIGHT DIAM 4.88 m LENGTH 28.04 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	636	318	227	Refrigerated	590
PRESSURE	kPa	241	586	827		89.6
TEMPERATURE	K	244 ÷ 672				≥ 219

EXHAUST

MASS FLOW	kg/s	636
PRESSURE	kPa	2.7
TEMPERATURE	K	

TRANSIENTS: Full engine transients

REMARKS: Test cell plenum has two inlets, one for heated and the other for refrigerated air. The exhaust duct is water cooled.

MEASURING EQUIPMENT: Large quantity equipment of transducers, signal conditioners, recorders and indicators was carefully selected to provide optimum performance and reliability for a wide variety of testing requirements.

600 aerodynamic pressure channels

256 temperature channels

132 low-speed general purpose channels (200 samples/s max.)

200 high-speed general purpose channels (20,000 samples/s max.)

Other types of instrumentation systems supplied with the test article can be accommodated.

DATA ACQUISITION AND PROCESSING: Computer controlled digital data acquisition system (SEL 800) includes two real time CRT graphics display systems, analog recorders (magnetic tape, strip chart, oscillographs), indicators, motion picture and television systems.

PUBLICATION ETC

AEDC Test Facilities Handbook, June 1979
S.GALL, F.X. FLOYD
Icing Test Capability of the Engine Test Facility Propulsion Development Test Cell (J-1)
Report No AEDC - TR - 71 - 94

3 CONTACT :

Arnold Engineering Development Center
AEDC/DOX
Arnold Air Force Station
Tennessee 37389 USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 24.4 km

FLIGHT MACH N° - 3.3

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
AEDC Arnold Engineering Development Center	Arnold Air Force Station Tennessee USA	Propulsion Development Test Cell J 2

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet	
Ram-Jet	Direct Connect	

SIZE : WIDTH HEIGHT DIAM 6.10 m LENGTH 31.4 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	636	318	227
PRESSURE	kPa	241	586	827
TEMPERATURE	K	244 ÷ 672		

EXHAUST

MASS FLOW	kg/s	636
PRESSURE	kPa	2.7
TEMPERATURE	K	

TRANSIENTS: Full engine transients

REMARKS: Water-cooled exhaust duct.

MEASURING EQUIPMENT: Large quantity equipment of transducers, signal conditioners, recorders and indicators was carefully selected to provide optimum performance and reliability for a wide variety of testing requirements.

600 aerodynamic pressure channels

344 temperature channels

104 low-speed general purpose channels (200 s/s max)

200 high-speed general purpose channels (20,000 s/s max)

Other types of instrumentation systems supplied with the test article can be accommodated.

DATA ACQUISITION AND PROCESSING: Computer controlled digital data acquisition system (SEL 800) includes two real time CRT graphics display systems, analog recorders (magnetic tape, strip chart, oscillographs), indicators, motion picture and television systems.

PUBLICATION ETC: AEDC Test Facilities Handbook, June 1979

3 CONTACT :

Arnold Engineering Development Center
AEDC/DOX
Arnold Air Force Station
Tennessee 37389 USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 24.4 km

FLIGHT MACH N° ÷ 3.0

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
AEDC Arnold Engineering Development Center	Arnold Air Force Station Tennessee USA	Propulsion Development Test Cell T-1

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet	
Ram-Jet	Direct Connect	

SIZE : WIDTH HEIGHT DIAM 3.75 m LENGTH up to 22.9m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	363	227
PRESSURE	kPa	241	483
TEMPERATURE	K	189 ÷ 652	

EXHAUST

MASS FLOW	kg/s	363
PRESSURE	kPa	2.7
TEMPERATURE	K	

TRANSIENTS

REMARKS

Free jet and wind tunnel aerodynamic testing can be performed using available nozzles at subsonic Mach numbers and at Mach numbers 1.2; 1.6; 2.0 and 3.0.
Test article installation is accomplished through the aft end of the test cell by removal of the exhaust ducting and aft portion of the cell.

MEASURING EQUIPMENT

Thrust 134 kN
Large quantity equipment of transducers, signal conditioners, recorders and indicators was carefully selected to provide optimum performance and reliability for a wide variety of testing requirements.

300 aerodynamic pressure channels

288 temperature channels

192 high speed general purpose channels (20,000 samples/s max)

Other types of instrumentation systems supplied with the test article can be accommodated.

DATA ACQUISITION AND PROCESSING

Computer controlled data acquisition system (SEL 700) includes limited on-line and quick-look capability.

PUBLICATION ETC

AEDC Test Facilities Handbook, June 1979

3 CONTACT :

Arnold Engineering Development Center
AEDC/DOX
Arnold Air Force Station
Tennessee 37389
USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 24.4 km

FLIGHT MACH N° - 3.0

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
AEDC Arnold Engineering Development Center	Arnold Air Force Station Tennessee USA	Propulsion Development Test Cell T-2

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet	
Ram-Jet	Direct Connect	
Turbo-Prop		

SIZE : WIDTH HEIGHT DIAM 3.75 m LENGTH up to 20.7 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	363	227
PRESSURE	kPa	241	483
TEMPERATURE	K	189 ÷ 652	

EXHAUST

MASS FLOW	kg/s	363
PRESSURE	kPa	2.7
TEMPERATURE	K	

TRANSIENTS

REMARK: Test article installation is accomplished through the aft end of the test cell by removal of the exhaust ducting and aft portion of the cell.

MEASURING EQUIPMENT: Thrust 134 kN
Large quantity equipment of transducers, signal conditioners, recorders and indicators was carefully selected to provide optimum performance and reliability for a wide variety of testing requirements.

300 aerodynamic pressure channels

288 temperature channels

192 high-speed general purpose channels (20,000 samples/s max)

Other types of instrumentation systems supplied with the test article can be accommodated.

DATA ACQUISITION AND PROCESSING: Computer controlled data acquisition system (SEL 700) includes limited on-line and quick-look capability.

PUBLICATION ETC: AEDC Test Facilities Handbook, June 1979

3 CONTACT :

Arnold Engineering Development Center
AEDC/DOX
Arnold Air Force Station
Tennessee 37389 USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 24.4 km

FLIGHT MACH N° ÷ 3.0

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
AEDC Arnold Engineering Development Center	Arnold Air Force Station Tennessee USA	Propulsion Development Test Cell T-4

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet	
Ram-Jet	Direct Connect	

SIZE : WIDTH HEIGHT DIAM 3.75 m LENGTH 16.8 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	363	227
PRESSURE	kPa	241	483
TEMPERATURE	K	189 ÷ 652	

EXHAUST

MASS FLOW	kg/s	363
PRESSURE	kPa	2.7
TEMPERATURE	K	

TRANSIENTS

REMARK Test article installation is accomplished through the aft end of the test cell by removal of the exhaust ducting and aft portion of the cell, alternatively an overhead hatch is available.

MEASURING EQUIPMENT Thrust 134 kN
Large quantity equipment of transducers, signal conditioners, recorders and indicators was carefully selected to provide optimum performance and reliability for a wide variety of testing requirements.

300 aerodynamic pressure channels

288 temperature channels

192 high-speed general purpose channels (20,000 samples/s max)

Other types of instrumentation systems supplied with the test article can be accommodated.

DATA ACQUISITION AND PROCESSING Computer controlled data acquisition system (SEL 700) includes limited on-line and quick-look capability.

PUBLICATION ETC AEDC Test Facilities Handbook, June 1979

3 CONTACT :

Arnold Engineering Development Center
AEDC/DOX
Arnold Air Force Station
Tennessee 37389 USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 24.4 km

FLIGHT MACH N° ÷ 3.0

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NAPC Naval Air Propulsion Center	Trenton New Jersey USA	Altitude Chamber 3 E

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet Ram-Jet	Direct Connect	Icing Test

SIZE : WIDTH HEIGHT DIAM 5.18 m LENGTH 9.14 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	318
PRESSURE	kPa	5.7 ÷ 507
TEMPERATURE	K	219 ÷ 616

EXHAUST

MASS FLOW	kg/s	318
PRESSURE	kPa	1.0
TEMPERATURE	K	2200

TRANSIENTS

TECHNICAL EQUIPMENT

Ram air facility	Variable exhaust diffusers
Refrigeration	Exhaust Gas Cooler
Heaters	Vacuum Exhausters

Quick response inlet and exhaust control valves

Inlet System Icing Capability

0.50 kg/s at $25 \cdot 10^{-6}$ m droplet size (via 100 spray nozzles)

0.19 kg/s at $15 \cdot 10^{-6}$ m droplet size (via 100 spray nozzles)

MEASURING EQUIPMENT: Thrust 222 kN

DATA ACQUISITION AND PROCESSING: Central on-line data acquisition and computation system with real time output of test data on a control room CRT, also on-line tape data storage

PUBLICATION ETC

J.F. BOYTOS, J. LEZNIAK
NAPTC Facility Modifications Required for Altitude Testing of Current V/STOL Engine. Report No NAPC-PE-102 (May 1977)

3 CONTACT :

Resource Management Officer (RM)
Naval Air Propulsion Center
Operations and Plant Engineering Dep.
P.O. Box 7176
Trenton, New Jersey 08628, USA

Phone
609-882-1414
Exts. 298/373

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 24.4 km

FLIGHT MACH N° ÷ 2.4

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NAPC Naval Air Propulsion Center	Trenton New Jersey USA	Altitude Chamber 1E and 2E

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Direct Connect	Icing Test

SIZE : WIDTH HEIGHT DIAM 4.42 m LENGTH 5.50 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	195
PRESSURE	kPa	5.7 ÷ 284
TEMPERATURE	K	219 ÷ 472

EXHAUST

MASS FLOW	kg/s	195
PRESSURE	kPa	1.0
TEMPERATURE	K	2200

TRANSIENTS

TECHNICAL EQUIPMENT

Ram air facility — Fixed exhaust diffusers
Refrigeration — Exhaust gas cooler
Heaters — Vacuum exhausters
Quick response inlet and exhaust control valves
Inlet System Icing Capability
0.50 kg/s at $25 \cdot 10^{-6}$ m droplet size (via 100 spray nozzles)
0.19 kg/s at $15 \cdot 10^{-6}$ m droplet size (via 100 spray nozzles)

MEASURING EQUIPMENT

Thrust 133 kN

DATA ACQUISITION AND PROCESSING

Central on-line data acquisition and computation system with real time output of test data on a control room CRT, also on-line tape data storage

PUBLICATION ETC

3 CONTACT :

Resource Management Officer (RM)
Naval Air Propulsion Center
Operations and Plant Engineering Dep.
P.O. Box 7176
Trenton, New Jersey 08628, USA

Phone
609-882-1414
Exts. 298/373

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 24.4 km

FLIGHT MACH N° ÷ 3.0

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
AEDC Arnold Engineering Development Center	Arnold Air Force Station Tennessee USA	Propulsion Development Test Cell T-6

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet Direct Connect	

SIZE : WIDTH HEIGHT DIAM 0.91 m LENGTH 5.50 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	170
PRESSURE	kPa	483
TEMPERATURE	K	219 ÷ 652

EXHAUST

MASS FLOW	kg/s	170
PRESSURE	kPa	2.7
TEMPERATURE	K	

TRANSIENTS

REMARK Test cell T-6 consists of a 2.14 m diameter inlet plenum chamber, the test section, and an exhaust diffuser. T-6 is preferably used for specific tests of rocket engines.

MEASURING EQUIPMENT Large quantity equipment of transducers, signal conditioners, recorders and indicators was carefully selected to provide optimum performance and reliability for a wide variety of testing requirements.

100 aerodynamic pressure channels

36 temperature channels

192 high-speed general purpose channels (20,000 samples/s max)

Other types of instrumentation systems supplied with the test article can be accommodated.

DATA ACQUISITION AND PROCESSING Computer controlled data acquisition system (SEL 700) includes limited on-line and quick look capability.

PUBLICATION ETC AEDC Test Facilities Handbook, June 1979

3 CONTACT :

Arnold Engineering Development Center
AEDC/DOX
Arnold Air Force Station
Tennessee 37389 USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 24.4 km

FLIGHT MACH N°

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
United Technologics Corp. Chemical Systems Div.	Coyote Center Component Development Laboratory	IRR Ground Test Facility

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Ramjet (Integral Rocket Ramjet Prop. Systems)		1) Rocket to Ramjet Operation 2) Complete Ramjet Flight Trajectory Tests

SIZE : WIDTH HEIGHT DIAM LENGTH

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY		Transition and ramjet ignition	High altitude cruise	
MASS FLOW	kg/s	45.4 ÷ 81.6	2.3 ÷ 9	storage capacity 13 600 kg air
PRESSURE	kPa	55.2 ÷ 96.5	5.5	compressed to 16.9 MPa maximum
TEMPERATURE	K	555 ÷ 667	667 ÷ 1111	

EXHAUST				
MASS FLOW	kg/s	4.5	18	Steam driven ejector
PRESSURE	kPa	3.5	34.5	Steam accumulator produces 34000 kg of steam at a rate of 34 kg/s
TEMPERATURE	K			

TRANSIENTS: according to flight trajectory fully controlled by computer

MAJOR COMPONENTS: Air Supply System, vitiated air heaters, liquid flow system, altitude simulationsystem, thrust stand, ramjet ignition system, test control center

DATA ACQUISITION CAPABILITY

Signal Conditioning:

Resistance bridge	36 channels
Voltage (thermocouple)	48 "
Flow	6 "
Events	12 "

Recording:

Wide-band FM tape (0 - 20 kHz)	18 "
Narrow band FM tape (0 - 2 kHz)	48 "
Data logger (25 channels/s)	110 "
Crossbar scanner (36 ch/s)	36 "
Direct write oscillograph(0-300Hz)	36 "
Direct write chart (0-100 Hz)	16 "
Quick-look data printout	2 "

DATE PROCESSING: by four basic systems: analogue processing, frequency analysis, quick look conversion and computation, digital data reduction.

PUBLICATION ETC: T. D. Myers, G. Stromberg: Ground Test Facility for Integral Rocket Ramjet Engines, AIAA-Paper 78 - 934, AIAA and SAE 14th Joint Propulsion Conference, July 1978, Las Vegas

3 CONTACT :

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL)	24.4	km
FLIGHT MACH N°	÷ 1.5	

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
AEDC Arnold Engineering Development Center	Arnold Air Force Station Tennessee USA	Propulsion Development Test Cell T-5

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet	Fuel Temperature Conditioning 219 ÷ 350 K
Ram-Jet	Direct Connect	

SIZE : WIDTH HEIGHT DIAM 2.14 m LENGTH 5.20 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY		continuously		from storage (214 m^3 at 27.6 MPa)
MASS FLOW	kg/s	41	18	45
PRESSURE	kPa	276	1379	1724
TEMPERATURE	K	227 ÷ 616		
EXHAUST				
MASS FLOW	kg/s	170		
PRESSURE	kPa	2.7		
TEMPERATURE	K			

TRANSIENTS

REMARK: The test cell T-5 is designed for small aerodynamic tests and tests of small turbofan, turbojet and ram-jet engines (simulated air launched starts, inlet total pressure distortion).

MEASURING EQUIPMENT: Thrust 22 kN
Large quantity equipment of transducers, signal conditioners, recorders and indicators was carefully selected to provide optimum performance and reliability for a wide variety of testing requirements.

240 aerodynamic pressure channels

192 temperature channels

200 high-speed general purpose channels (20,000 samples/s max)

Other types of instrumentation systems supplied with the test article can be accommodated.

DATA ACQUISITION AND PROCESSING: Computer controlled data acquisition system (SEL 700) includes limited on-line and guide-look capability.

PUBLICATION ETC: **AEDC Test Facilities Handbook, June 1979**

3 CONTACT :

Arnold Engineering Development Center
AEDC/DOX
Arnold Air Force Station
Tennessee 37389 USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 21.3 km

FLIGHT MACH N° ÷ 4.0 ::

:: for PSL - 3 only ÷ 3.0

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NASA	Lewis Research Center Cleveland, Ohio, USA	PSL - 4 (also TC - 4) PSL - 3 (also TC - 3)

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Direct Connect	

SIZE : WIDTH HEIGHT DIAM 7.3 m LENGTH 11.9 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

		Chamber Design Criteria	Central Supply System Capacity		
SUPPLY					
MASS FLOW	kg/s	340	218	174	17
PRESSURE	kPa	1138	414	1138	3206
TEMPERATURE	K	227 - 624	Heating 127 kg/s at 1138 kPa up to 960 K		
EXHAUST			Cooling 181 kg/s to 205 K		
MASS FLOW	kg/s	340			
PRESSURE	kPa	4.4			
TEMPERATURE	K	2200			

TRANSIENTS

MEASURING EQUIPMENT

Thrust 178 kN (present engine mount structure limit)
445 kN (maximum bed limit)

600 pressures, utilizing 25 scanivalves
72 pressures, one strain gauge transducer/channel
384 temperatures
30 frequencies
24 accelerometers

DATA ACQUISITION AND PROCESSING

1 On-site

1.1 SEL 8600 Digital Comp
- steady state data acquisition
- on-line monitor and record
- limits monitor
- equipments and systems control

1.2 EAI 680 Analog Comp.
- on-line computation of high response information
- control of dynamic inlet pressure distortion system

also various recorders (tape, oscillographs, plotter) 75 channels strain gauge monitor equipment

2 Remote central recording location

2.1 Analog Record
Multi-level input (5 mV-2 V)
195 channels FM multiplexed
DC to 8 kHz response

2.2 Digital Record
Up to 30,000 samples/s from up to 200 input signals. Quick look playback to test cell.

PUBLICATION ETC

3 CONTACT :

Director, Propulsion Systems Laboratory
NASA Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 21.3 km

FLIGHT MACH N° ÷ 2.5

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls Royce Ltd. Aero Div. Derby	Sinfin A Site Derby U.K.	Altitude Test Facility Cell 1 Cell 2

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet Turbo-Shaft (one cell only) Reheat-Systems	Free Jet Direct Connect	

SIZE : WIDTH 3.81 m HEIGHT 2.75 m DIAM 3.81 m (second cell) LENGTH 11.5 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	180
PRESSURE	kPa	500
TEMPERATURE	K	193 ÷ 453

EXHAUST

MASS FLOW	kg/s	272
PRESSURE	kPa	2.75
TEMPERATURE	K	2100

TRANSIENTS: Full transient capability for testing gas turbine engines from idling to max. mil. rating in 5 s (stability in 10 s)

REMARK: Two test cells run alternately. Six 17.5 MW exhausters/compressors electrically driven.

MEASURING EQUIPMENT: Thrust 90 kN, shaft power 4500 kW

240 pressures 9 fuel flows
178 temperatures 3 speeds

DATA ACQUISITION AND PROCESSING: Full automatic data recording by on-line computer.

PUBLICATION ETC

3 CONTACT :

Rolls Royce Ltd
Aero Division Derby
P.O. Box 31
Derby DE 2 8BJ
U.K.

Phone
0352 - 42424

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 21.3 km

FLIGHT MACH N° ÷ 3.0

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NASA	Lewis Research Center Cleveland, Ohio USA	PSL-1 (TC-1) PSL-2 (TC-2)

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet Ram-Jet	Direct Connect	

SIZE : WIDTH HEIGHT DIAM 4.27 m LENGTH 7.32 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	204
PRESSURE	kPa	310
TEMPERATURE	K	277 ÷ 624

EXHAUST

MASS FLOW	kg/s	204
PRESSURE	kPa	4.4
TEMPERATURE	K	

TRANSIENTS

PUBLICATION ETC

3 CONTACT :

Director, Propulsion Systems Laboratory
NASA Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 20.0 km

FLIGHT MACH N° ÷ 4.0

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
CEPr Centre d'Essais des Propulseur	Saclay Orsay France	R 5

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet Direct Connect	

SIZE : WIDTH HEIGHT DIAM 5.5 m LENGTH 30.0 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	375
PRESSURE	kPa	700
TEMPERATURE	K	923

EXHAUST

MASS FLOW	kg/s	375
PRESSURE	kPa	5.0
TEMPERATURE	K	2073

TRANSIENTS

MEASURING EQUIPMENT: Thrust 300 kN
1000 channels

PUBLICATION ETC

3 CONTACT :

M. le Directeur
Centre d'Essais des Propulseurs
Saclay
91406 Orsay
France

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 20.0 km

FLIGHT MACH N° ÷ 2.4

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
CEPr Centre d'Essais des Propulseurs	Saclay Orsay France	R 3 R 4

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet Direct Connect	

SIZE : WIDTH HEIGHT DIAM 3.50 m LENGTH 18.00 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	200
PRESSURE	kPa	200
TEMPERATURE	K	208 ÷ 473

EXHAUST

MASS FLOW	kg/s	200
PRESSURE	kPa	5.0
TEMPERATURE	K	

TRANSIENTS

MEASURING EQUIPMENT Thrust 200 kN
600 channels

PUBLICATION ETC

3 CONTACT :

M. le Directeur
Centre d'Essais des Propulseurs
Saclay
91406 Orsay
France

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 20.0[1] km

FLIGHT MACH N° 2.2 [2]

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
University of Stuttgart	Vaihingen Stuttgart F.R. of Germany	HPT

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet	Free jet	
Ramjet	Direct connect	
Turboshaft		

SIZE : WIDTH HEIGHT DIAM 3.00 m LENGTH 10.00 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	70
PRESSURE	kPa	196
TEMPERATURE	K	200 ÷ 450

EXHAUST

MASS FLOW	kg/s	70
PRESSURE	kPa	7.3
TEMPERATURE	K	

TRANSIENTS: full engine and flight environment transients

REMARKS:
1) Maximum altitude for turboshaft engines 16 km
2) Maximum Mach-No at sea level 1.0

The altitude test facility for turbo- and ram-engines is a multi-role highly adaptable test facility which permits also testing of components like compressors, turbines, combustion chambers.

MEASURING EQUIPMENT: Thrust 100 kN, shaft power 4500 kW

DATA ACQUISITION AND PROCESSING: Two data acquisition systems

ZME 4	and	ZME 2	
216		144	pressure channels
130		48	temperature channels
20		12	frequencies/speeds

ZME 4 + 2: On-line display of test parameters and data recording on punched cards with subsequent processing on central computer

PUBLICATION ETC: Höhenprüfstand für Turboflugtriebwerke
Beschreibung der Anlage ILA 80 A - 04

3 CONTACT :

Prof. Dr.-Ing. W. Braig
Institut für Luftfahrtantriebe
Universität Stuttgart
Pfaffenwaldring 6
7000 Stuttgart 80 (Vaihingen)
F.R. of Germany

Phone 711 - 7841
Telex 07 255 727

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 19.8 km

FLIGHT MACH N°

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NAPC Naval Air Propulsion Center	Trenton New Jersey USA	Altitude Chamber 3 W

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Shaft	Direct Connect	

SIZE : WIDTH 2.44 m HEIGHT 2.44 m DIAM LENGTH 4.57 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	45.4
PRESSURE	kPa	5.76 ÷ 142
TEMPERATURE	K	219 ÷ 378

EXHAUST

MASS FLOW	kg/s	45.4
PRESSURE	kPa	2.7
TEMPERATURE	K	

TRANSIENTS

TECHNICAL EQUIPMENT

Ram air facility — Exhaust gas cooler
Air heater/cooler — Vacuum exhauster
Water brakes
Fuel temperature conditioner 0.38 kg/s 216 ÷ 247 K

MEASURING EQUIPMENT

Hydraulic Dynanometer CLAYTON MODEL TP 6000
4400 kW; 600 ÷ 1600 min^{-1}

DATA ACQUISITION AND PROCESSING

Central on-line data acquisition and computation system with real time output of test data on a control room CRT. Full printer listings; tape data storage

PUBLICATION ETC

3 CONTACT :

Resource Management Officer (RM)
Naval Air Propulsion Center
Operations and Plant Engineering Dep.
P.O. Box 7176
Trenton, New Jersey 08628, USA

Phone
609-882-1414
Exts. 298/373

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 19.8 km

FLIGHT MACH N°

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NAPC Naval Air Propulsion Center	Trenton New Jersey USA	Altitude Chamber 4 W

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Shaft	Direct Connect	Salt environment facility

SIZE : WIDTH HEIGHT DIAM 3.05 m LENGTH 6.10 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	45.4
PRESSURE	kPa	5.76 ÷ 203
TEMPERATURE	K	219 ÷ 378

EXHAUST

MASS FLOW	kg/s	45.4
PRESSURE	kPa	2.7
TEMPERATURE	K	

TRANSIENTS

TECHNICAL EQUIPMENT

Ram air facility	Exhaust gas cooler
Air heater/cooler	Vacuum exhausters
Water brakes	Salt environment facility

Fuel temperature conditioner 0.38 kg/s 216 ÷ 347K

MEASURING EQUIPMENT

Thrust 89 kN; shaft power 4400 kW

108 pressure channels	10 frequencies
160 temperature channels	20 analog signals

DATA ACQUISITION AND PROCESSING Central on-line data acquisition and computation system with real time output of test data on a control room CRT. Full printer listings; tape data storage

PUBLICATION ETC

3 CONTACT :

Resource Management Officer (RM)
Naval Air Propulsion Center
Operations and Plant Engineering Dep.
P.O. Box 7176
Trenton, New Jersey 08628, USA

Phone
609-882-1414
Exts. 298/373

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 19.8 km

FLIGHT MACH N°

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NAPC Naval Air Propulsion Center	Trenton New Jersey USA	Altitude Chamber 5 W

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Shaft	Direct Connect	

SIZE : WIDTH 2.90 m HEIGHT 2.90 m DIAM LENGTH 5.18 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	45.4
PRESSURE	kPa	5.76 ÷ 203
TEMPERATURE	K	219 ÷ 378

EXHAUST

MASS FLOW	kg/s	45.4
PRESSURE	kPa	2.7
TEMPERATURE	K	

TRANSIENTS

TECHNICAL EQUIPMENT

Ram air facility — Exhaust gas cooler
Air heater/cooler — Vacuum exhausters
Water brakes
Fuel temperature conditioner 0.38 kg/s 216 ÷ 347 K

MEASURING EQUIPMENT

Shaft power 4400 kW
108 pressures — 10 frequencies
160 temperatures — 20 analog signal

DATA ACQUISITION AND PROCESSING

Central on-line data acquisition and computation system with real time output of test data on a control room CRT. Full printer listings; tape data storage

PUBLICATION ETC

3 CONTACT :

Resource Management Officer (RM)
Naval Air Propulsion Center
Operations and Plant Engineering Dep.
P.O. Box 7176
Trenton, New Jersey 08628, USA

Phone
609-882-1414
Exts. 298/373

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 19.8 km

FLIGHT MACH N°

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NAPC Naval Air Propulsion Center	Trenton New Jersey USA	Accessories & small engine environmental Chamber 6 W

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Shaft	Direct Connect	Test of Starters and APUs

SIZE : WIDTH 3.05 m HEIGHT 3.05 m DIAM LENGTH 5.18 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	45.4
PRESSURE	kPa	5.76 ÷ 203
TEMPERATURE	K	219 ÷ 378

EXHAUST

MASS FLOW	kg/s	45.4
PRESSURE	kPa	2.7
TEMPERATURE	K	

TRANSIENTS

TECHNICAL EQUIPMENT

Ram air facility — Exhaust gas cooler

Air heater/cooler — Vacuum exhausters

Water brakes

Fuel temperature conditioner 0.38 kg/s 216 - 347 K
220 kW electrical motor adjustable speed 0 ÷ 20,000 min^{-1}
(accessories drive)

MEASURING EQUIPMENT

Shaft power 4400 kW

DATA ACQUISITION AND PROCESSING

Central on-line data acquisition and computation system with real time output of test data on a control room CRT.
Full printer listings; tape data storage

PUBLICATION ETC

3 CONTACT :

Resource Management Officer (RM)
Naval Air Propulsion Center
Operations and Plant Engineering Dep.
P.O. Box 7176
Trenton, New Jersey 08628
USA

Phone
609-882-1414
Exts. 298/373

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 19 km

FLIGHT MACH N° 3.5

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NGTE National Gas Turbine Establishment	Pyestock Farnborough UK	Altitude Test Facility Cell 3

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet Ramjet	Direct Connect/Free-jet	Icing Test

SIZE : WIDTH HEIGHT DIAM 6 m LENGTH 24 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	270 max
PRESSURE	kPa	200 max
TEMPERATURE	K	200 to 740 (870 for special installations)

EXHAUST

MASS FLOW	kg/s	270
PRESSURE	kPa abs	38 (Min pres 11.3)
TEMPERATURE	K	2000

TRANSIENTS: Full engine transients

REMARKS: Connected tests can be made on engines such als Olympus 593, Pegasus, or Spey. Performance evaluation, engine handling, altitude relight and icing trials are possible.

MEASURING: Thrust measuring capacity up to 220 kN

EQUIPMENT: Standard facilities for 200 individual temperatures and 300 individual pressures plus shaft speed and fuel flow

DATA ACQUISITION AND PROCESSING: On-line processing (at data processing center) and display

PUBLICATION ETC

3 CONTACT :

Director
NGTE
Pyestock
Farnborough GU14 OLS
Hants
UK

Phone Farnborough 44411
Telex 858231

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 18 km

FLIGHT MACH N° Subsonic

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NGTE National Gas Turbine Establishment	Pyestock Farnborough UK	Altitude Test Facility Cell 3W

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet	Direct Connect/Free-jet	Icing Test

SIZE : WIDTH HEIGHT DIAM 7.5 m LENGTH 17 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	630 max
PRESSURE	kPa abs	ambient max
TEMPERATURE	K	236 to ambient

EXHAUST

MASS FLOW	kg/s	630
PRESSURE	kPa abs	48 (Min pres 11.3)
TEMPERATURE	K	800

TRANSIENTS: Full engine transients

REMARKS: Connected tests of high by-pass ratio turbofans in the 180-220 kN thrust class, also icing trials on helicopters fuselage.

MEASURING EQUIPMENT: Thrust measuring capacity up to 220 kN

Standard facilities for 200 individual temperatures and 300 individual pressures plus shaft speed and fuel flow

DATA ACQUISITION AND PROCESSING: On-line processing (at data processing center) and display

PUBLICATION ETC

P. F. ASHWOOD An Altitude Test Facility for Large Turbofan Engines
Journ. Aircraft, Vol. 10, pp 468-474 (1973)

3 CONTACT :

Director
NGTE
Pyestock
Farnborough GU14 OLS
Hants
UK

Phone Farnborough 44411
Telex 858231

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) - 17 km

FLIGHT MACH N° - 2.5

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NGTE National Gas Turbine Establishment	Pyestock Farnborough UK	Altitude Test Facility Cell 2

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Ram-Jet	Direct Connect	
Turbo-Jet		

SIZE : WIDTH HEIGHT DIAM 3.7 m LENGTH 37 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	180 max
PRESSURE	kPa abs	910 max
TEMPERATURE	K	ambient to 490 max

EXHAUST

MASS FLOW	kg/s	77
PRESSURE	kPa abs	50 (min pressure 14)
TEMPERATURE	K	2000

TRANSIENTS: Full engine transients

REMARKS: Cell 2 is used for connected testing of reheat systems without an engine and for a wide variety of tests on jet engines including tests at conditions representing low altitude and high subsonic speed. Cells exhausted by four air driven ejectors.

MEASURING EQUIPMENT: Thrust measuring capacity up to 220 kN

Standard facilities for 200 individual temperatures and 300 individual pressures plus shaft speed and fuel flow

DATA ACQUISITION AND PROCESSING: On-line processing (at data processing center) and display

PUBLICATION ETC: General description and background
Engineering June 14, 21, 28 (1957)

3 CONTACT :

Director
NGTE
Pyestock
Farnborough GU14 OLS
Hants
UK

Phone Farnborough 44411
Telex 858231

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 15.0 km

FLIGHT MACH N° > 2.0

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
CEPr Centre d'Essais des Propulseurs	Saclay Orsay France	S 1

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet Ram-Jet Turbo-Shaft	Free Jet Direct Connect	

SIZE : WIDTH HEIGHT DIAM 3.5 m LENGTH 15.5 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	100	
PRESSURE	kPa	200	10 ÷ 700
TEMPERATURE	K	623	

EXHAUST

MASS FLOW	kg/s	100	
PRESSURE	kPa	5	
TEMPERATURE	K	293 ÷ 1073	

TRANSIENTS

MEASURING EQUIPMENT: Thrust 100 kN shaft power 2000 kW
400 channels

DATA ACQUISITION AND PROCESSING: Central computer

PUBLICATION ETC

3 CONTACT :

M. le Directeur
Centre d'Essais des Propulseurs
Saclay
91406 Orsay
France

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 13.7 km

FLIGHT MACH N° 1

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
United Technologies Corp. Pratt & Whitney Aircraft Division	Andrew Willgoos Turbine Laboratory	X - 217

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet	Direct connect	

SIZE : WIDTH HEIGHT DIAM 5.5 m LENGTH 10.7 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	545
PRESSURE	kPa	86.2
TEMPERATURE	K	305

EXHAUST

MASS FLOW	kg/s
PRESSURE	kPa
TEMPERATURE	K

TRANSIENTS

MEASURING EQUIPMENT AND DATA ACQUISITION AND PROCESSING

1. Steady State Data Acquisition System
   687 measurements including pressures, temperatures, speeds, flows, and thrust.
   All channels recorded within 90 sec. Processing for quick look purposes takes 3.5 - 5 minutes. Information in the form of final data and plots is available within 3 hours.
2. Transient Digital Data Systems
   Analogue data are digitized and recorded on magnetic tapes
   Three modes of operation
   - single record (steady state)
   - intervalometer (steady state and slow transient)
   - gapped continnous (fast transient recording)

   20 000 data points/sec. 400 channels maximum
   Speed depends on number of channels recorded i.e. 50 data point per channel and second minimum.
3. MARS = Multiplexed Analogue Recording System
   providing a record of the various parameters immediately before and during a failure.

PUBLICATION ETC G. D. Adamson Jet Engine Test Facilities: Laboratories for Tomorrow's Engines. ASME 71-WA/GT-12

3 CONTACT :

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 13.7 km

FLIGHT MACH N°

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NRC National Research Council Canada	NRC DME Bldg M10-B Ottawa, Ontario Canada	NRC Altitude facility

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE

Turbo-Jet

Turbo-Shaft
(small engines only)

TEST SECTION CONFIGURATION

SPECIAL CAPABILITY

SIZE : WIDTH HEIGHT DIAM 2.13 m LENGTH 3.66 m

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	
PRESSURE	kPa	
TEMPERATURE	K	335 kW air refrigeration system

EXHAUST

MASS FLOW	kg/s	1.8 ÷ 5.4
PRESSURE	kPa	7 ÷ 21
TEMPERATURE	K	

TRANSIENTS

PUBLICATION ETC

3 CONTACT :

R.A. Tyler
Gas Dynamics Laboratory
Division of Mechanical Engineering
National Research Council
Ottawa, Ontario K 1A OR6
Canada

Phone
613-993-2442

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 11.0[1] km

FLIGHT MACH N° ÷ 1.0

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
CEPr Centre d'Essais des Propulseurs	Saclay Orsay France	C 1

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet Turbo-Shaft	Free Jet Direct Connect	

SIZE : WIDTH HEIGHT DIAM 3.2 m LENGTH 8.0 m[2]

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	50
PRESSURE	kPa	50 ÷ 120
TEMPERATURE	K	208 ÷ 353

EXHAUST

MASS FLOW	kg/s	55
PRESSURE	kPa	5
TEMPERATURE	K	633

TRANSIENTS

REMARK [1] Max Altitude for turbo-shaft engines 5.6 km
[2] Cylindrical vacuum chamber, position of one bulkhead adaptable

MEASURING EQUIPMENT Thrust 10 kN Shaft Power 2000 kW
200 channels

DATA ACQUISITION AND PROCESSING Central computer

PUBLICATION ETC

3 CONTACT :

M. le Directeur
Centre d'Essais des Propulseurs
Saclay
91406 Orsay
France

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 10.0 km

FLIGHT MACH N° 0.1 ÷ 1.0

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
CEPr Centre d'Essais des Propulseurs	Saclay Orsay France	R 2

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet	Icing Test
Turbo-Shaft		

SIZE : WIDTH HEIGHT DIAM 3.5 m[1] LENGTH

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	
PRESSURE	kPa	
TEMPERATURE	K	223

water content 6 ÷ 10 g/m^3

mean volumetric diam of water droplets 15 ÷ 30 · 10^{-6} m

(under certain conditions) 40 · 10^{-6} m

EXHAUST

MASS FLOW	kg/s
PRESSURE	kPa
TEMPERATURE	K

TRANSIENTS

REMARK [1] Maximum inlet diameter of vacuum test chamber for icing flow condition 1.15 m, below this diameter adaptable to test article.

MEASURING EQUIPMENT

Apparati used for measuring droplet diameter and water contact:

- PMS probe (Dr. Knollenberg)
- Fusil Napier
- Aquasonde of French National Meteorological Service
- turning cylinder
- Ruskin's apparatus

PUBLICATION ETC

3 CONTACT :

Mr. I.A. Fagegaltier
Centre d'Essais des Propulseurs
Saclay
91406 Orsay
France

Phone
1-941.81.50
Ext. 713

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) 10.0 km

FLIGHT MACH N° 0.1 ÷ 1.0

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
CEPr Centre d'Essais des Propulseurs	Saclay Orsay France	R 6

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbo-Jet	Free Jet	Icing Test
Turbo-Shaft		

SIZE : WIDTH HEIGHT DIAM 5.5 m[1] LENGTH

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s		water content	6 ÷ 10 g/m^3
PRESSURE	kPa		mean volumetric diam of water droplets	15 ÷ 30 · 10^{-6} m
TEMPERATURE	K	223	(under certain conditions)	40 · 10^{-6} m

EXHAUST

MASS FLOW	kg/s
PRESSURE	kPa
TEMPERATURE	K

TRANSIENTS

REMARK [1] Maximum inlet diameter of vacuum test chamber for icing flow condition 1.7 m, below this diameter adaptable to test article.

MEASURING EQUIPMENT Apparati used for measuring droplet diameter and water contact:

- PMS probe (Dr. Knollenberg)
- Fusil Napier
- Aquasonde of French National Meteorological Service
- turning cylinder
- Ruskin's apparatus

PUBLICATION ETC

3 CONTACT :

Mr. I.A. Fagegaltier
Centre d'Essais des Propulseurs
Saclay
91406 Orsay
France

Phone
1-941.81.50
Ext. 713

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) km

FLIGHT MACH N°

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Pratt & Whitney Aircraft Division	Florida Research and Development Center	A 1 (JT-11 Test Stand)

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE: Turbojet

TEST SECTION CONFIGURATION:

SPECIAL CAPABILITY:

SIZE : WIDTH HEIGHT DIAM LENGTH

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

SUPPLY

MASS FLOW	kg/s	o Heated inlet air supply - 113.5 kg/s up to 755 K by a J-75 jet engine
PRESSURE	kPa	
TEMPERATURE	K	o Injection of demineralized water for temperature control

EXHAUST

MASS FLOW	kg/s	o Exhaust ejector for improved pressure recovery
PRESSURE	kPa	o Engine is shrouded to simulate high temperature ambient air
TEMPERATURE	K	

TRANSIENTS

MEASURING EQUIPMENT: Thrust 267 kN (445 kN)

PUBLICATION ETC

3 CONTACT :

Pratt & Whitney Aircraft Division
Florida Research and Development Center
P.O. Box 2691
West Palm Beach, Florida 33402
USA

6 ALTITUDE TEST CELLS

ALTITUDE (MAX. NOMINAL) km

FLIGHT MACH N°

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Pratt & Whitney Aircraft Division	Florida Research and Development Center	High Mach Number Altitude Ram Test Stand C-4 and C-5 [1]

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE: Turbo-Jet

TEST SECTION CONFIGURATION:

SPECIAL CAPABILITY:

SIZE : WIDTH HEIGHT DIAM LENGTH

AIR CONDITIONING, SUPPLY, AND EXHAUST CAPACITY

			Heated air non vitiated	vitiated
SUPPLY				
MASS FLOW	kg/s	218 ÷ 182	113.5	57
PRESSURE	kPa	237 ÷ 406	406	406
TEMPERATURE	K		up to 644	up to 700
EXHAUST				
MASS FLOW	kg/s	9.1 ÷ 54.5		
PRESSURE	kPa	5.1 ÷ 50.8		
TEMPERATURE	K			
TRANSIENTS				

REMARK [1] C-5 test stand has atmospheric inlet capability

DATA ACQUISITION AND PROCESSING: Automatic data recording

PUBLICATION ETC

3 CONTACT :

Pratt & Whitney Aircraft Division
Florida Research and Development Center
P.O. Box 2691
West Palm Beach, Florida 33402
USA

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls Royce Ltd. Aero Division Derby	Hucknall England	TB No 9

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet	Free-jet	Noise Intake Compatibility Cross Wind X-Ray Foreign Object Damage

SIZE:	WIDTH	HEIGHT	DIAMETER	LENGTH

DESCRIPTION/COMMENT: The master open air performance test bed accepts large fan engines

SPECIAL EQUIPMENT: Mobile measuring equipment for transients

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	Unlimited
PRESSURE	kPa	Ambient
TEMPERATURE	K	Ambient

MEASURING EQUIPMENT: Thrust 310 kN

DATA ACQUISITION AND PROCESSING: Automatic data recording system

PUBLICATION

3 CONTACT:

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls Royce Ltd Aero Division Bristol (Site rented by RR from Procurement Executive, Ministry of Defense)	Aston Down Nr. Strond Glos. England	Main Engine Test Site (A + B)

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet	Free jet Field	Icing Noise Vectored Thrust Foreign Object Damage

SIZE:	WIDTH	HEIGHT	DIAMETER	LENGTH
	6320 m^2	concrete area		

DESCRIPTION/COMMENT: Depending on type, engines can be mounted on a choice of stands on either of two alternative adjacent sites. The star board side allows hardstanding mounting. Foie and aft and lateral noise recording up to 46 m radius.

SPECIAL EQUIPMENT: Vans equipped with transient u/v, straingauge and portable data logging.

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	Unlimited
PRESSURE	kPa	Ambient
TEMPERATURE	K	Ambient

MEASURING EQUIPMENT: Thrust 222 kN forward, 67 kN reverse

In addition to all basic engine driving instrumentation:

100 pressures up to 2760 kPa (gas)
20 pressures up to 13790 kPa (liquid)
60 temperatures thermocouples (12 alarms)
12 temperatures resistance (6 alarms)

DATA ACQUISITION AND PROCESSING: Manual

PUBLICATION

3 CONTACT:

R. F. Jeffery
Assistant Chief Engineer,Test Operations
Rolls Royce Ltd, Aero Division Bristol
P.O. Box 3
Bristol, England

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NAPC Naval Air Propulsion Center	NAS, Lakehurst New Jersey USA	Variable Attitude Stand

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet		Attitude
Turboshaft		Jet Deflection
		Twin Engine Test

SIZE: WIDTH HEIGHT DIAMETER LENGTH

DESCRIPTION/COMMENT: The test facility consists a variable attitude wing section and supports on which the wing and engine height can be varied from 1.5 to 7.6 m above the ground, a thrust, torque and engine rotation system and a control station containing the control and recording equipment.

SPECIAL EQUIPMENT: Pitch attitude speed between 0 and 2 rpm. Automatic dead weight compensation at all attitudes, capability of testing either a single engine or two engines simultaneously in a 1.5 to 12.2 m wing span.

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	Unlimited
PRESSURE	kPa	Ambient
TEMPERATURE	K	Ambient

MEASURING EQUIPMENT:

thrust	0 - 222 kN	over a range of
torque	0 - 67 kN	pitch angles from -45° to $+105^{\circ}$
shaft power	0 - 8.8 MW	roll angles from -30° to $+30^{\circ}$

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

Resource Management Officer
Code RM
Naval Air Propulsion Center
P. O. Box 7176
Trenton, New Jersey 08628, USA

Phone:
609 - 882 - 1414
Ext. 298 or 373

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NAPC	NAS, Lakehurst	Turntable Test
Naval Air Propulsion Center	New Jersey	Facility
	USA	

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet		Noise
Turboshaft		IR-Signature

SIZE: WIDTH HEIGHT DIAMETER LENGTH

DESCRIPTION/COMMENT

SPECIAL EQUIPMENT

The facility consists of a thrust measurement table and engine stand mounted on a modified 127 mm/38 twin gun mount carriage. The carriage is used as the turning mechanism. The gun base rotates in a horizontal plane over a range of - 100° to + 100°. All types of engines can be installed on this stand. The engine can be locked at the various angles where thrust can be directly read out and continuously recorded during test operation. Characteristics of the stand are: thrust 0 to 222 kN, rotation direction - clockwise and counterclockwise, maximum rotations 200°, plane of rotation - horizontal, fixed speed of rotation - 0.23 rad/sec, turning table can be rotated and locked remotely at any angle with engine running, and maximum live load is 0 to 11340 kg.

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	Unlimited
PRESSURE	kPa	Ambient
TEMPERATURE	K	Ambient

MEASURING EQUIPMENT: Thrust 222 kN

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

Resource Management Officer
Code RM
Naval Air Propulsion Center
P. O. Box 7176
Trenton, New Jersey 08628, USA

Phone:
609 - 882 - 1414
Ext. 298 or 373

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
CEPr Centre d'Essais des Propulseurs	Saclay Orsay France	Tx (Banc d'essais d'ingestion)

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet Turboshaft	Field	Foreign Object Damage

SIZE: WIDTH HEIGHT DIAMETER LENGTH

DESCRIPTION/COMMENT Concrete area (55 m x 25 m) consisting of three main parts
- one protected zone for shooting at fixed targets
- one open air zone
- a control cabin usable for either zone

SPECIAL EQUIPMENT

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	Unlimited
PRESSURE	kPa	Ambient
TEMPERATURE	K	Ambient

MEASURING EQUIPMENT Thrust 180 kN
250 parameters

DATA ACQUISITION AND PROCESSING Automatic data logging and processing by computer

PUBLICATION

3 CONTACT:

M'le Directeur
Centre d'Essais des Propulseurs
Saclay
91406 Orsay, France

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls Royce Ltd	Hucknall England	TB No 5

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet Turboshaft	Free jet	Foreign Object Damage Intake Compatibility Twin Engine

SIZE:	WIDTH	HEIGHT	DIAMETER	LENGTH

DESCRIPTION/COMMENT: General purpose open air test bed capable of twin engine installation.
Not suitable for large fan engines

SPECIAL EQUIPMENT

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	Unlimited
PRESSURE	kPa	Ambient
TEMPERATURE	K	Ambient

MEASURING EQUIPMENT: Thrust 2 x 90 kN
Pressures, temperatures, speeds, all manual

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls Royce Ltd.	Hucknall England	TB No 7

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet	Free jet	Noise
Turboshaft		Intake Compatibility
		Cross Wind

SIZE: WIDTH HEIGHT DIAMETER LENGTH

DESCRIPTION/COMMENT: Open air performance test bed suitable for noise testing.
Intake test with cross wind.
Not suitable for large fan engines

SPECIAL EQUIPMENT

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	Unlimited
PRESSURE	kPa	Ambient
TEMPERATURE	K	Ambient

MEASURING EQUIPMENT: Thrust 90 kN (Reverse 45 kN)
Pressures, temperatures, speeds, thrust, all manual

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
United Technologies Corp. Pratt & Whitney Aircraft Florida Research and Development Center	West Palm Beach Florida USA	A - 8

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet		Heated Inlet

SIZE: WIDTH HEIGHT DIAMETER LENGTH

DESCRIPTION/COMMENT

Thrust: No thrust measurement is available on this stand. The thrust block is rated at 445 kN maximum force.

Fuel-System: Three independent fuel systems can supply jet fuels with flows up to 10 kg/s at 690 kPa (gauge) and ambient temperature.

SPECIAL EQUIPMENT

Natural gas is available at flow rates up to 1.9 kg/s at 3.1 MPa (gauge)

Compressed Air System: 2.65kg/s of air at 690 kPa and ambient temperature is available for engine starting and motoring.

AIR SUPPLY CAPACITY

MASS FLOW	kg/s
PRESSURE	kPa
TEMPERATURE	K

A direct fired gas heater can heat 22.7 kg/s air to 422 K to simulate fan discharge temperatur to a core engine. The heater is connected to automatic controls which provide timed engine acceleration and deceleration cycles to achieve endurance testing on engine parts.

MEASURING EQUIPMENT

Test stand A-8 is not tied into Automatic Data and Acquisition Systems. However, manually read instrumentation is available in the test stand and consists of manometers (36 each by 2 m), vibration meters (4). Thermocouple readouts (1 vertical Brown with 56 channels), gauges (30), speed and flow digital readouts, over-temperature module, PLA programmer, timing and abort modules, RCVV schedule, HIGV error detector and temperature module, and heater gas controls.

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

AD-A105 194 ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT--ETC F/G 14/2
AIR-BREATHING ENGINE TEST FACILITIES REGISTER,(U)
JUL 81 J H KRENGEL
UNCLASSIFIED AGARD-AG-269 NL

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls Royce Ltd	Hucknall England	TB No 10

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet	Free jet	Foreign Object Damage Intake Compatibility Cross Wind

SIZE: WIDTH HEIGHT DIAMETER LENGTH

DESCRIPTION/COMMENT: Closed test cell - non thrust measuring, accept large fan engine,
design capacity 310 kN

SPECIAL EQUIPMENT: Computer controlled automatic throttle

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	907	
PRESSURE	kPa	ambient	exhaust pressure 148 kPa (abs)
TEMPERATURE	K	ambient	exhaust temperature 1100 K

MEASURING EQUIPMENT

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls Royce Ltd Aero Division Bristol	Gipsy Patch South Bristol England	TP 105 / 137

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet	TP 105	Foreign Object Damage
	TP 105 + TP 137	Vectored Thrust Endurance

SIZE: WIDTH 11.9 m HEIGHT 13.4 m DIAMETER LENGTH 21 m
TP 137 24 m

DESCRIPTION/COMMENT / SPECIAL EQUIPMENT: This bed has been designed for use with the Pegasus range of engines. It has a cradle mounted engine which is suspended beneath the test stand the centre line of the engine being 4 m above ground level. The hot and cold jet flows are collected in four ducts and joined to issue into a common detuner. This procedure allows adequate detuner cooling without water injection in TP 105. In TP 137 provision for reheat work is made by providing reheat fuel flow and collector duct cooling capabilities.

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	536 through splitters
PRESSURE	kPa	atmospheric
TEMPERATURE	K	ambient — exhaust temperature 773 K, dry

MEASURING EQUIPMENT: Thrust 178 kN vertical
178 kN horizontal
44.5 kN reverse

250/350 pressure lines
200/190 temperatur lines } manual readings

DATA ACQUISITION AND PROCESSING:
1. "On bed" RIKADENKI pen recorder with 6 channels to display any signal which can be converted to mV (i. e. speed, temperature, pressure, or flow)
2. "Plug in" caravan recording and monitoring of any parameters.
Closed circuit TV for engine monitoring.

PUBLICATION

3 CONTACT:

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Pratt & Whitney Aircraft of Canada Ltd	St. Hubert Quebec Canada	5 - 11

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet		Foreign Object Damage

SIZE:	WIDTH	HEIGHT	DIAMETER	LENGTH

DESCRIPTION/COMMENT: The system is capable of testing engines up to 22.3 kN thrust capacity. The engine is operated in free air conditions, i. e. ambient conditions of temperature, pressure, and wind velocity. Effect of winds below 4.5 m/s are considered negligible. Operation in winds above 4.5 m/s is acceptable, providing the wind direction is within an arc of 180° infront of the engine.

SPECIAL EQUIPMENT: gun capable of shooting 1.8 kg birds at 224 m/s

AIR SUPPLY CAPACITY

MASS FLOW	kg/s
PRESSURE	kPa
TEMPERATURE	K

MEASURING EQUIPMENT: Thrust 222 kN

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

K. H. Scholz
Manager, Test Support Engineering
Phone 677 - 9411 Ext. 619

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls Royce Ltd	Hucknall	TB No 8
Aero Division Derby	England	

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet	Free jet	Cold Start
Turboshaft		

SIZE: WIDTH 6.1 m HEIGHT 6.1 m DIAMETER LENGTH 6.1 m

DESCRIPTION/COMMENT: Low temperature starting facility for all types of RR engines,
large fan engines with restricted massflow

SPECIAL EQUIPMENT

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	204	
PRESSURE	kPa	ambient	exhaust pressure 138 kPa (gauge)
TEMPERATURE	K	219 K	exhaust temperature 1100 K

MEASURING EQUIPMENT: Thrust 133 kN

DATA ACQUISITION AND PROCESSING: Measurement engineering mobile caravan with automatic data reduction link with Derby computer.

PUBLICATION

3 CONTACT:

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NAPC	Trenton	SLC 1 W
Naval Air Propulsion Center	New Jersey	SLC 2 W
	USA	

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet		Icing
Turboshaft		Water Ingestion
		Corrosion
		Hot + Cold Start

SIZE: WIDTH 7 m HEIGHT 4.3 m DIAMETER LENGTH 17.1 m

DESCRIPTION/COMMENT: This facility consists of Sea Level Test Cells for testing air breathing engines at flight MACH-numbers up to 1.1. Liquid air from a 53 m^3 storage tank is piped to the inlet of each cell. A spray bar with nozzles is used to distribute the liquid air in the air stream. This system supplements mechanical refrigeration.

SPECIAL EQUIPMENT: The inlet section contains provision for water ingestion and icing tests of engines. Icing capability is 0.5 x 10^{-3} m^3/s at 25 x 10^{-6} m droplet size through 100 spray nozzles and 0.22 x 10^{-3} m^3/s at 15 x 10^{-6} m droplet size through 100 spray nozzles.

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	159	
PRESSURE	kPa	5.75 ÷ 284	maximum continuous
TEMPERATURE	K	219 ÷ 377	exhaust temperature 2200 K

MEASURING EQUIPMENT: Thrust 133 kN (flexure supported thrust stand)

DATA ACQUISITION AND PROCESSING

The facility is connected to a central on-line data acquisition and computation system with real time output of test data on a control room CRT.
Full printer listings and tape data storage are also performed on-line.

PUBLICATION

3 CONTACT:

Resource Management Offizer, Code RM
Naval Air Propulsion Center
P.O. Box 7176
Trenton, New Jersey 08628, USA

Phone 609 - 882 - 1414
Ext. 298 or 373

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
MTU Motoren- und Turbinen-Union München GmbH	Manching Ingolstadt F. R. Germany	Open Air Test Bed

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet	Free jet	Foreign Object Damage
	Field	Attitude

SIZE: WIDTH 6 m HEIGHT 6 m DIAMETER LENGTH 12 m

DESCRIPTION/COMMENT

Open air test bed which can be sheltered by mobile hangar suitable for testing of
- thrust reversing systems
- turbo-jet-engines with and without after burner e.g. RB 199

Noise measurements restricted.

SPECIAL EQUIPMENT

Engine turning mechanism: pitch angle $\pm 90^{o}$
Also possible is turning the engine around its centre line $\pm 20^{o}$ for testing the oil system and internal air system.
Equipment for bird ingestion tests (11 birds, Ma $\sim$ 1)

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	100
PRESSURE	kPa	ambient (test site 500 m above sea level)
TEMPERATURE	K	ambient; exhaust temperature 2000 K

MEASURING EQUIPMENT

Thrust 80 kN (40 kN reverse)
Measuring equipment conventional
Special equipment for measuring horizontal, vertical,and assymmetric reverse thrust.

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

Mr. Kirschey, Code EVP Phone 89 - 1489 - 708
Development Test Facilities
MTU - München GmbH
Dachauer Straße 665
8000 München 50, Federal Republic of Germany

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
DFVLR	Köln-Porz	VMK

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Ramjet	Free jet	Attitude

SIZE: WIDTH 4 m HEIGHT 4 m DIAMETER LENGTH 6 m

DESCRIPTION/COMMENT: The facility is a blow down windtunnel with vertical flow direction. A variety of axially symmetric nozzles in 3 sizes of up to 312 mm diameter is available. The test cell is built in reinforced concrete withstanding explosion pressures up to 500 kPa.

SPECIAL EQUIPMENT: Flight Mach number range: subsonic - 3.2
quick change of pressure
change of angle of attack 2°/sec; range $\pm$ 15°.

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	$\leq$ 90
PRESSURE	kPa	$\leq$ 3500 kPa (stagnation pressure)
TEMPERATURE	K	$\leq$ 770 K (stagnation temperature)

MEASURING EQUIPMENT

Thrust	10 kN
Forces:	3- and 6-component balances
Pressures:	pressure transducers, scanivalves
Temperatures:	thermocouples, thermovision
Others:	Schlierenoptics, high speed camera

DATA ACQUISITION AND PROCESSING

Hewlett-Packard HP 2116 B, on-line

PUBLICATION: DLR - FB 65 - 24

3 CONTACT:

E.-O. Krohn
Institut für Experimentelle Strömungsmechanik
DFVLR
Postfach 906058
5000 Köln 90, Federal Republic of Germany
Phone: 2203-601-2278

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
NRC National Research Council	Ottawa Ontario Canada	No 4 TC (Engine Laboratory)

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet	Free jet	Icing

SIZE: WIDTH 7.5 m HEIGHT 7.5 m DIAMETER LENGTH 18 m

DESCRIPTION/COMMENT: The permanently installed icing test facilities permit the generation of supercooled water droplets and of ice particles, as well as the admission of natural snow into the icing duct. Tests are being carried out under ambient pressures, but two air ejectors enable the simulation of forward flight velocity for a limited bypass stream. A heat exchanger provides limited air cooling, but tests depend basically on ambient temperature conditions.

SPECIAL EQUIPMENT

Supercooled water droplets	15-40 µm, calibrated
Ice particles	10-500 µm, random
Snow	natural snow collected and injected into air duct
Simulated flight velocity	up to 190 m/s (430 mph) engine and ejector combined, depending on geometry of bypass duct
Air cooling	10°C at a mass flowrate of 27 kg/s

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	15 and 5	;	180
PRESSURE	kPa	600	1000	ambient
TEMPERATURE	K			

MEASURING EQUIPMENT

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

Mr. E.H. Dudgeon Tel. 613-993-2425
Section Head
Engine Laboratory
Division of Mechanical Engineering
National Research Council Canada
Montreal Road
OTTAWA, Ontario. K1A OR6

Mr.W. Grabe
Tel. 613-993-2214
Engine Laboratory
Division of Mechanical Engineering
National Research Council
Canada, Montreal Road
OTTAWA, Ontario. K1A OR6

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Pratt & Whitney Aircraft of Canada Ltd. Longueuil, Quebec Canada	Longueuil Quebec Canada	1 - 11 A

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet Turboshaft		Cold Start

SIZE:	WIDTH	HEIGHT	DIAMETER	LENGTH

DESCRIPTION/COMMENT: This cell is used to evaluate and investigate cold starting characteristics of small turbine engines. Air/methanol heat exchangers are used to cool the air in the test chamber.

SPECIAL EQUIPMENT: The air circulation fan provides approximately three air changes per minute. Two completely separate cooling systems, each with a centrifugal pump for methanol circulation are provided. These may be operated together or independently as required.

AIR SUPPLY CAPACITY

MASS FLOW	kg/s
PRESSURE	kPa
TEMPERATURE	K

MEASURING EQUIPMENT

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

K. H. Scholz
Manager, Test Support Engineering
Pratt & Whitney Aircraft of Canada Ltd
Longueuil, Quebec
Canada

Phone 677 - 9411
Ext. 619

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
CEPr Centre d'Essais des Propulseur	Saclay Orsay France	H 9

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turbojet Turboshaft	Free jet	Attitude

SIZE:	WIDTH	HEIGHT	DIAMETER	LENGTH

DESCRIPTION/COMMENT

SPECIAL EQUIPMENT turntable, range - 30° to + 30°
angular speed range 1 to 60°/s

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	
PRESSURE	kPa	ambient
TEMPERATURE	K	ambient

MEASURING EQUIPMENT Thrust 2 kN, Shaft Power 2000 kW
100 parameters

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

M. le Directeur
Centre d'Essais des Propulseurs
Saclay
91406 Orsay, France

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls-Royce Ltd Aero Division	Victory Road Derby England	Hangar "H"

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turboshaft		Engine with propeller

SIZE: WIDTH 7.9 m HEIGHT 7.9 m DIAMETER LENGTH 44 m

DESCRIPTION/COMMENT: This facility is a propeller hangar incorporating a wing section which is capable of running turbo-shaft engines up to 6700 kW.
Maximum diameter of propeller: 4.9 m

SPECIAL EQUIPMENT

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	1800
PRESSURE	kPa	atmospheric
TEMPERATURE	K	atmospheric

MEASURING EQUIPMENT: shaft power 6700 kW
manual

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

Rolls Royce Ltd, Aero Division, Derby DE 2 8 BJ, U.K.

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls-Royce (Canada) Limited	Pie / X Bld. Montreal Quebec	T 64 (Prop test cell)

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turboshaft		Engine with propeller

SIZE:	WIDTH	HEIGHT	DIAMETER	LENGTH

DESCRIPTION/COMMENT: The T 64 Turbo Prop is tested, using a RCAF slave propeller. It is a torque reaction installation. (Fuel JP 4).

SPECIAL EQUIPMENT

AIR SUPPLY CAPACITY

MASS FLOW	kg/s
PRESSURE	kPa
TEMPERATURE	K

MEASURING EQUIPMENT: Shaft Power 2200 kW

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

Director of Quality
Rolls Royce (Canada) Limited
9500 Cote de Liesse Road
Lachine, Quebec
Canada H4Y 1 B 7

Phone 514 - 631 - 3541

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls-Royce Ltd	Hatfield	TB No 16

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turboshaft		Twin Engine Test

SIZE: WIDTH 4.9 m HEIGHT 7.6 m DIAMETER LENGTH 11.6 m

DESCRIPTION/COMMENT Gnome twin wessex engines with coupling gear box

SPECIAL EQUIPMENT

AIR SUPPLY CAPACITY

MASS FLOW kg/s

PRESSURE kPa

TEMPERATURE K

MEASURING EQUIPMENT Shaft Power 1860 kW

DATA ACQUISITION AND PROCESSING

Mobile recording caravan

PUBLICATION Aero- and Industrial Test Facilities Manual (Section 16)

3 CONTACT:

T. Goswell, RR Site Manager Phone Hatfield 63830
Manor Road
Hatfield
England

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls Royce	Hatfield	TB No 15

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turboshaft		Pre-heated air

SIZE: WIDTH 4.9 m HEIGHT 2 m DIAMETER LENGTH 8.2 m

DESCRIPTION/COMMENT Helicopter turbo-shaft development test bed

SPECIAL EQUIPMENT

AIR SUPPLY CAPACITY

MASS FLOW kg/s

PRESSURE kPa

TEMPERATURE K

MEASURING EQUIPMENT Shaft Power 1470 kW

DATA ACQUISITION AND PROCESSING

Mobile recording caravan

PUBLICATION Aero- and Industrial Test Facilities Manual (Section 16)

3 CONTACT:

T. Goswell, R.R Site Manager Phone Hatfield 63830
Manor Road
Hatfield
England

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls Royce	Hatfield	TB No 12 13 13 A

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turboshaft	Free jet	Pre-heated air

SIZE: WIDTH 4.9 m HEIGHT 2.7 m DIAMETER LENGTH 6 m

DESCRIPTION/COMMENT Helicopter turbo-shaft development test beds

SPECIAL EQUIPMENT

AIR SUPPLY CAPACITY

MASS FLOW kg/s

PRESSURE kPa

TEMPERATURE K

MEASURING EQUIPMENT Shaft Power 1100 kW
U.V. Trace Recorders

DATA ACQUISITION AND PROCESSING

Automatic Data Recording schemed for 1980

PUBLICATION Aero- and Industrial Test Facilities Manual (Section 16)

3 CONTACT:

T. Goswell, RR Site Manager Phone Hatfield 63830
Manor Road
Hatfield
England

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Pratt & Whitney Aircraft of Canada Ltd.	Longueuil Canada	1 - 1 1 - 6 1 - 18 2 - 4

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turboshaft		Engine with propeller

SIZE:	WIDTH	HEIGHT	DIAMETER	LENGTH

DESCRIPTION/COMMENT: Propeller test cells used for testing the PT-6 turboprop engines. Cells are of the "L"-type configuration. Engine is mounted on an overhead stand accomodating propellers up to 3.35 m diameter.

SPECIAL EQUIPMENT

AIR SUPPLY CAPACITY

MASS FLOW	kg/s	385
PRESSURE	kPa	ambient
TEMPERATURE	K	ambient

MEASURING EQUIPMENT: Shaft Power 956 kW

Test cells are fully instrumented for endurance performance and other tests.

DATA ACQUISITION AND PROCESSING

PUBLICATION

3 CONTACT:

K. H. Scholz, Manager, Test Support Engineering
Pratt & Whitney Aircraft of Canada Ltd.
Longueuil, Quebec
Canada
Phone: 677-9411
Ext. 619

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Rolls-Royce Ltd.	Hatfield England	TB No 21

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turboshaft		Engine with propeller

SIZE: WIDTH 4.8 m HEIGHT 4.9 m DIAMETER LENGTH 42.7 m

DESCRIPTION/COMMENT: Prop-shaft engine ASTAZOU 16 D test bed Hangar test facility capable of full engine flight clearance test with propeller fitted, including reverse pitch operation. (propeller diam. 2.64 m).

SPECIAL EQUIPMENT

AIR SUPPLY CAPACITY

MASS FLOW	kg/s
PRESSURE	kPa
TEMPERATURE	K

MEASURING EQUIPMENT: Shaft Power 662 kW
U. V. trace
Singer analyzer

DATA ACQUISITION AND PROCESSING

Recording caravan

PUBLICATION: Aero- and Industrial Test Facilities Manual (Section 16)

3 CONTACT:

T. Goswell, RR Site Manager Phone Hatfield 63830
Manor Road
Hatfield
England

7 SEA LEVEL TEST CELLS

IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Plessey Comp. Ltd.	Abbey Works Titchfield Fareham, Hampshire England	PASTF (Plessey Aerospace Test Facility)

TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turboshaft	Direct connect	Icing Foreign Object Damage Noise Vibration Vectored Thrust

SIZE: WIDTH 4.6 m HEIGHT 2.7 m DIAMETER LENGTH 9.1 m

DESCRIPTION/COMMENT Six cells

SPECIAL EQUIPMENT Spin rig; inertia rig; cold box to 203 K soak
to 233 K operation
Hot testing at 323 K AIT and up to 403 K unit casing temperature
Vibration 31 kN thrust (10 G at 2.9 kN; 30 G at 0.8 kN)

AIR SUPPLY CAPACITY		Free Air	Compressed Air			Exhaust
MASS FLOW	kg/s	4.5	1.22	1.83	2.44	2.3
PRESSURE	kPa		4137	2758	689.5	ambient
TEMPERATURE	K	233 ÷ 323				

MEASURING EQUIPMENT Shaft Power: 2 223 kW
2 112 kW
8 56 kW
6 19 kW
Dynamometers

Pressure, temperature, and flow measuring devices covering air and fuel management techniques

DATA ACQUISITION AND PROCESSING

UV and pen recorders, micro-processor equipment, cine cameras and video tape processes.

PUBLICATION

CONTACT

W. Renton, Test Facilities Manager, Test Work
R. B. Matthews, Deputy Engineering Executive
Engineering and Development Work
Plessey Comp. Ltd., Abbey Works
Titchfield, Fareham, Hampshire, England

Phone: Titchfield 43031 Ext. 2428
Ext. 2401

7 SEA LEVEL TEST CELLS

1 IDENTIFICATION

ORGANISATION	LOCATION	TEST CELL DESIGNATION
Alfa Romeo	Napoli Italy	Hangar Test Bed

2 TECHNICAL DATA/CAPACITIES

TYPE OF ENGINE	TEST SECTION CONFIGURATION	SPECIAL CAPABILITY
Turboshaft	Free jet	Engine with propeller

SIZE: WIDTH 5 m HEIGHT 6 m DIAMETER LENGTH 14 m

DESCRIPTION/COMMENT maximum diameter of propeller 2.3 m

SPECIAL EQUIPMENT

AIR SUPPLY CAPACITY

MASS FLOW kg/s

PRESSURE kPa

TEMPERATURE K

MEASURING EQUIPMENT

DATA ACQUISITION AND PROCESSING

Microcomputer for data acquisition
Minicomputer for real time data analysis
Main data storage on IBM 30/33

PUBLICATION

3 CONTACT:

Dott. Ing. G. Balassone - Technical Director
Alfa Romeo, Pomigliano d'Arco, Napoli, Italy

Tel. 8841 344
Telex 710 083 ALFAPO

APPENDIX I

1. MEMBERS OF SUBCOMMITTEE 01 OF THE PROPULSION AND ENERGETICS PANEL

Dr. J.G. Mitchell, Chairman
Director of Corporate Planning
Headquarters Arnold Engineering
Development Center (AFSC)
Arnold AF Station, Tennessee 37389, U.S.A.

Dr. R.B. Whyte
Fuels and Lubricants Laboratory
Division of Mechanical Engineering
National Research Council
Ottawa, Ontario K1A OR6, Canada

M.I'Ingénieur Principal D. Mouranche
Service Technique Aéronautique
Section Moteurs
4 Ave. de la Porte d'Issy
75996 Paris Armées, France

Dr. D.K.Hennecke
Motoren und Turbinen Union GmbH (MTU)
Abt. EW
Dachauerstrasse 665
8000 München 50, Fed. Rep. of Germany

Professor C. Casci
Politecnico di Milano
Istituto di Macchine
Piazza Leonardo da Vinci 32
20133 Milano, Italy

Dr. Ing. G. Maoli
Fiat s.p.A.
Via L. Bissolati 57
00187 Roma, Italy

Ir.J.P.K. Vleghert
National Aerospace Laboratory
P.O. Box 90502
Anthony Fokkerweg 2
1059 CM Amsterdam, The Netherlands

Mr. A.J.B. Jackson
Rolls Royce Limited
Aero Division
P.O. Box 31
Derby DE2 8BJ, England

Mr. A.A. Martino
Manager, Research and Technology Group
Naval Air Propulsion Center (Code PE-4)
P.O. Box 7176
Trenton, New Jersey 08628, U.S.A.

2. PROPULSION AND ENERGETICS PANEL MEMBERS having solicited data or supported the activity otherwise.

M. le Professeur Ch. Hirsch
Vrije Universiteit Brussel
Dept. de Mécanique des Fluides
Pleinlaan 2
1050 Bruxelles, Belgique

Professor Dr. B. Qvale
Laboratoriet for Energiteknik
Polytekniske Laereanstalt
Bygning 403 B, Lundtoftvej 100
2800 Lyngby, Denmark

M.J.F. Chevalier
Ingénieur en Chef - Recherches
SNECMA
Centre d'Essais de Villaroche
77550 Moissy-Cramayel, France

Professor Dr.-Ing. G. Winterfeld
DFVLR Institut für Antriebstechnik
Postfach 906058
5000 Köln 90, Fed.Rep. of Germany

Mr. G. Kristofersen
Norwegian Defence Research
Establishment
Division for Weapons & Equipment
P.O. Box 25
N-2007 Kjeller, Norway

Dr. Ahmet UCER
Middle East Technical University
O D T Ü
Makina Muh. Bölümü
Ankara, Turkey

Dr. J. Dunham
National Gas Turbine Establishment
Pyestock
Farnborough, Hants GU 14 OLS
England

Engineer Mario N.R. Nina
CTAMFUL
Instituto Superior Tecnico
Avenida Rovisco Pais
Lisboa 1, Portugal

Mr. H.I. Bush
Deputy Director,
Turbine Engine Division/ TB
Air Force Aero Propulsion Lab.
Wright-Patterson AFB, Ohio 45433, U.S.A.

APPENDIX II

Altitude Test Cell Information continued

1. PWT 16 S continued from page 6 - 1

Test section and supporting structure is an entire unit (test section cart) and removable from the tunnel. Five carts are available (two 12 m, three 6 m long) with different support systems (vertical strut pitching system, vertical pitch table, sting, special) Two carts have perforated walls for unchoking the test section near sonic speeds and for alleviating wall interference effects.

The same compressor drive system, with a total capacity of 166 MW, is used for both tunnels PWT 16 S and PWT 16 T. The main compressor of PWT 16 S consists of four axial-flow compressors(barrels), which are orientated such that any number from one to four barrels may be operated in series. The compressor operates at a constant speed of 600 rpm with volume flow adjustment provided by remotely controlled inlet guide vanes and stator blades of the first, second,and third barrels.

Various auxiliary supply systems are installed: electrical power systems, fuel systems, liquid propellant supply system, explosion and fire prevention system, high pressure auxiliary air supply systems.

2. PWT 16 T continued from page 6 - 6

Two carts have perforated walls for unchoking the test section near sonic speeds and for alleviating wall interference effects.

The same compressor drive system, with a total capacity of 166 MW, is used for both tunnels PWT 16 T and PWT 16 S. The tunnel 16 T compressor, which normally operates at a constant speed of 600 rpm, is a three-stage, axial-flow machine having a 9.14 m tip diameter and a hub-to-tip ratio of 0.6. The inlet guide vanes and the three interstage stator rows of the compressor are remotely controllable through an angle range that satisfies the range of volume flow requirements. Subsynchronous, variable speed operation is also possible and this extends the tunnel operating range to low subsonic Mach numbers.

Various auxiliary supply systems are installed: electrical power systems, fuel systems, liquid propellant supply system, explosion and fire prevention system, high pressure auxiliary air supply system.

8.3 APPENDIX III : ABBREVIATIONS [1)]

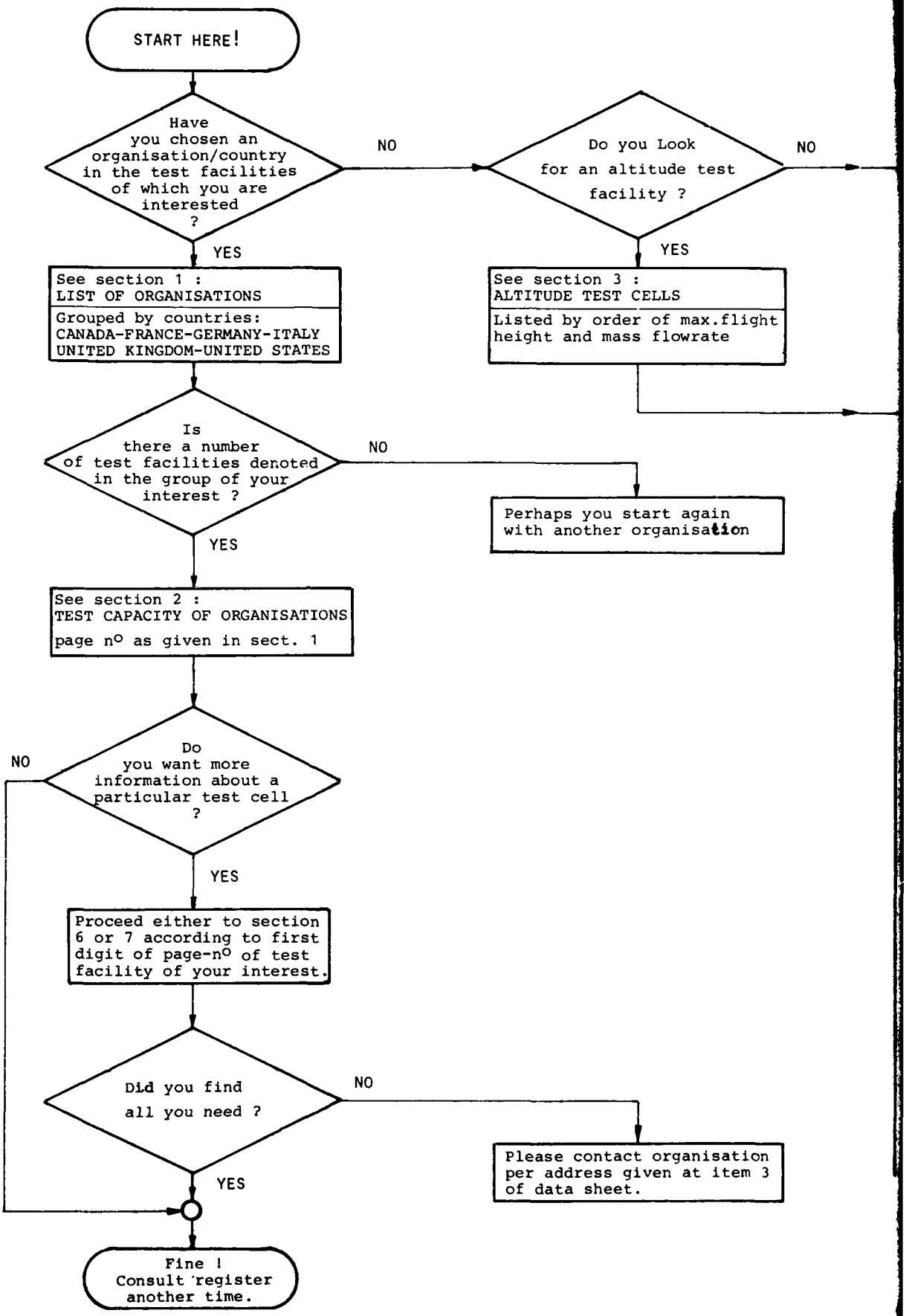
AIRes.	AIResearch Manufacturing Co.
AEDC	Arnold Engineering Development Center
AFAPL	Air Force Aero Propulsion Laboratory
AR	Alfa Romeo
BR	Bristol
CA	California
CC-AMPD	Confederation College of Applied Arts & Technology Aviation & Motive Power Department
CEPr	Centre d'Essais des Propulseurs
CRT	Cathode Ray Tube
CT	Connecticut
CU-GTL	Carleton University Gas Turbine Laboratory
DCU	Data Collection Unit
DDAD	General Motors Corporation Detroit Diesel Allison Division
DE	Derby
DFVLR	Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt e.V.
EM	Costruzioni Aeronautiche G. Agusta Elicotteri Meridionali
FIAT	Fiat Aviazione S.p.A.
FL	Florida
FOD	Foreign Object Damage
GE	General Electric Co.
H	Height
HA	Hatfield
HU	Hucknall
IRR	Integral Rocket Ramjet
JHU-APL	The Johns Hopkins University Applied Physics Laboratory
L	Length
LUCAS	Lucas Aerospace Limited
MAR	The Marquardt Co.
MTU	Motoren- und Turbinen-Union München GmbH
NAPC	Naval Air Propulsion Center
NASA-LE	National Aeronautics and Space Administration Lewis Research Center
NGTE	National Gas Turbine Establishment
NPT	Noel Penny Turbines Limited
NRC	National Research Council Canada

[1)] Test Cell Designations, Engine Designations, and SI-Units not included

8.3 APPENDIX III : ABBREVIATIONS [1)]

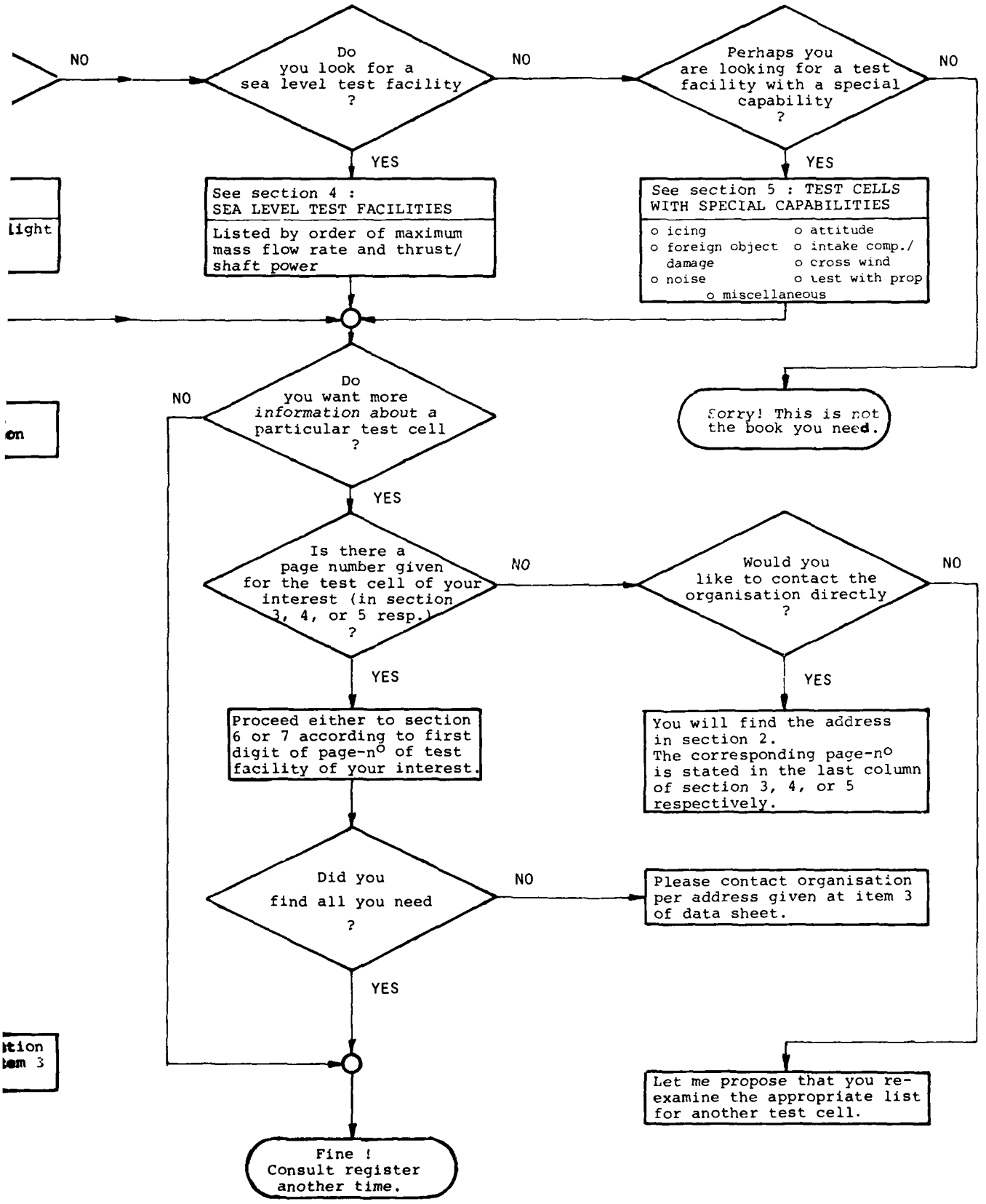
PL	Plessey Company Limited
P&W-AC	Pratt & Whitney Aircraft of Canada Ltd.
P&W-AW	United Technologies Corporation Pratt & Whitney Aircraft Division Commercial Products Division Andrew Willgoos Turbine Laboratory
P&W-FL	United Technologies Corporation Pratt & Whitney Aircraft Division Government Products Division Florida Research & Development Center
RJ	Ram-Jet
RR-BR	Rolls Royce Limited Aero Division, Bristol
RR-CA	Rolls Royce (Canada) Limited
RR-DE	Rolls Royce Limited Aero Division, Derby
RR-HA	Rolls Royce Limited, Hatfield
RR-HU	Rolls Royce Limited, Hucknall
SNECMA	Société Nationale d'Etude et de Construction de Moteurs d'Aviation
s/s	Samples/Second
TE-CAE	Teledyne CAE
TJ	Turbo-Jet (including Turbo-Fan)
TS	Turbo-Shaft
US-ILA	Universität Stuttgart Institut für Luftfahrt-Antriebe
UT-CSD	United Technologies Corporation Chemical Systems Division
W	Width
WE-CA	Westinghouse Canada Limited

[1)] Test Cell Designations, Engine Designations, and SI-Units not included


START HERE!
Have you chosen an organisation/country in the test facilities of which you are interested ?
NO
Do you Look for an altitude test facility ?
NO
YES
YES
See section 1 : LIST OF ORGANISATIONS
Grouped by countries: CANADA-FRANCE-GERMANY-ITALY UNITED KINGDOM-UNITED STATES
See section 3 : ALTITUDE TEST CELLS
Listed by order of max.flight height and mass flowrate
Is there a number of test facilities denoted in the group of your interest ?
NO
Perhaps you start again with another organisation
YES
See section 2 : TEST CAPACITY OF ORGANISATIONS
page nº as given in sect. 1
Do you want more information about a particular test cell ?
NO
YES
Proceed either to section 6 or 7 according to first digit of page-nº of test facility of your interest.
Did you find all you need ?
NO
YES
Please contact organisation per address given at item 3 of data sheet.
Fine ! Consult register another time.

APPENDIX IV

QUICK USER'S FLOW CHART



REPORT DOCUMENTATION PAGE

1. Recipient's Reference	2. Originator's Reference	3. Further Reference	4. Security Classification of Document
	AGARD-AG-269	ISBN 92-835-1394-0	UNCLASSIFIED

5. Originator Advisory Group for Aerospace Research and Development
North Atlantic Treaty Organization
7 rue Ancelle, 92200 Neuilly sur Seine, France

6. Title

AIR-BREATHING ENGINE TEST FACILITIES REGISTER

7. Presented at

8. Author(s)/Editor(s)

Joachim H.Krengel

9. Date

July 1981

10. Author's/Editor's Address

11. Pages

126

12. Distribution Statement This document is distributed in accordance with AGARD policies and regulations, which are outlined on the Outside Back Covers of all AGARD publications.

13. Keywords/Descriptors

Test facilities, test cells
Airbreathing engines
Jet engines
Turbofan engines
Turbo-shaft engines
Ramjet engines
Sea level test facilities
Altitude test facilities

14. Abstract

Complementary to the Symposium on 'Turbine Engine Testing', sponsored by the Propulsion and Energetics Panel, and held in Turin, Italy on 29 September–3 October 1980, a register of airbreathing engine test facilities was compiled, aimed at comprising the test facilities relevant for research and development in NATO countries. Included are test facilities being in use or under construction at the various research organizations, industrial firms, and universities.

Test facilities and their technical data are given as far as the response to a questionnaire was received or open literature was available. Nevertheless interested test engineers will be able to find whether a test facility suiting their specific demands already exists or may be easily adapted to their purposes.

In order to ease contacts with organizations, complete addresses are given and cross-reference from the lists of test facilities and their data sheets to the list of organizations or vice versa is possible.

This AGARDograph was prepared at the request of the Propulsion and Energetics Panel of AGARD.

AGARDograph No. 269 Advisory Group for Aerospace Research and Development, NATO AIR-BREATHING ENGINE TEST FACILITIES REGISTER Compiled by Joachim H.Krengel Published July 1981 126 pages Complementary to the Symposium on 'Turbine Engine Testing', sponsored by the Propulsion and Energetics Panel, and held in Turin, Italy on 29 September -3 October 1980, a register of airbreathing engine test facilities was compiled, aimed at comprising the test facilities relevant for research and development in NATO countries. Included are test facilities being in P.T.O.	AGARD-AG-269 Test facilities, test cells Airbreathing engines Jet engines Turbofan engines Turbo-shaft engines Ramjet engines Sea level test facilities Altitude test facilities	AGARDograph No. 269 Advisory Group for Aerospace Research and Development, NATO AIR-BREATHING ENGINE TEST FACILITIES REGISTER Compiled by Joachim H.Krengel Published July 1981 126 pages Complementary to the Symposium on 'Turbine Engine Testing', sponsored by the Propulsion and Energetics Panel, and held in Turin, Italy on 29 September -3 October 1980, a register of airbreathing engine test facilities was compiled, aimed at comprising the test facilities relevant for research and development in NATO countries. Included are test facilities being in P.T.O.	AGARD-AG-269 Test facilities, test cells Airbreathing engines Jet engines Turbofan engines Turbo-shaft engines Ramjet engines Sea level test facilities Altitude test facilities
AGARDograph No. 269 Advisory Group for Aerospace Research and Development, NATO AIR-BREATHING ENGINE TEST FACILITIES REGISTER Compiled by Joachim H.Krengel Published July 1981 126 pages Complementary to the Symposium on 'Turbine Engine Testing', sponsored by the Propulsion and Energetics Panel, and held in Turin, Italy on 29 September -3 October 1980, a register of airbreathing engine test facilities was compiled, aimed at comprising the test facilities relevant for research and development in NATO countries. Included are test facilities being in P.T.O.	AGARD-AG-269 Test facilities, test cells Airbreathing engines Jet engines Turbofan engines Turbo-shaft engines Ramjet engines Sea level test facilities Altitude test facilities	AGARDograph No. 269 Advisory Group for Aerospace Research and Development, NATO AIR-BREATHING ENGINE TEST FACILITIES REGISTER Compiled by Joachim H.Krengel Published July 1981 126 pages Complementary to the Symposium on 'Turbine Engine Testing', sponsored by the Propulsion and Energetics Panel, and held in Turin, Italy on 29 September -3 October 1980, a register of airbreathing engine test facilities was compiled, aimed at comprising the test facilities relevant for research and development in NATO countries. Included are test facilities being in P.T.O.	AGARD-AG-269 Test facilities, test cells Airbreathing engines Jet engines Turbofan engines Turbo-shaft engines Ramjet engines Sea level test facilities Altitude test facilities

use or under construction at the various research organizations, industrial firms, and universities.

Test facilities and their technical data are given as far as the response to a questionnaire was received or open literature was available. Nevertheless interested test engineers will be able to find whether a test facility suiting their specific demands already exists or may be easily adapted to their purposes.

In order to ease contacts with organizations, complete addresses are given and cross-reference from the lists of test facilities and their data sheets to the list of organizations or vice versa is possible.

This AGARDograph was prepared at the request of the Propulsion and Energetics Panel of AGARD.

ISBN 92-835-1394-0

use or under construction at the various research organizations, industrial firms, and universities.

Test facilities and their technical data are given as far as the response to a questionnaire was received or open literature was available. Nevertheless interested test engineers will be able to find whether a test facility suiting their specific demands already exists or may be easily adapted to their purposes.

In order to ease contacts with organizations, complete addresses are given and cross-reference from the lists of test facilities and their data sheets to the list of organizations or vice versa is possible.

This AGARDograph was prepared at the request of the Propulsion and Energetics Panel of AGARD.

ISBN 92-835-1394-0

use or under construction at the various research organizations, industrial firms, and universities.

Test facilities and their technical data are given as far as the response to a questionnaire was received or open literature was available. Nevertheless interested test engineers will be able to find whether a test facility suiting their specific demands already exists or may be easily adapted to their purposes.

In order to ease contacts with organizations, complete addresses are given and cross-reference from the lists of test facilities and their data sheets to the list of organizations or vice versa is possible.

This AGARDograph was prepared at the request of the Propulsion and Energetics Panel of AGARD.

ISBN 92-835-1394-0

use or under construction at the various research organizations, industrial firms, and universities.

Test facilities and their technical data are given as far as the response to a questionnaire was received or open literature was available. Nevertheless interested test engineers will be able to find whether a test facility suiting their specific demands already exists or may be easily adapted to their purposes.

In order to ease contacts with organizations, complete addresses are given and cross-reference from the lists of test facilities and their data sheets to the list of organizations or vice versa is possible.

This AGARDograph was prepared at the request of the Propulsion and Energetics Panel of AGARD.

ISBN 92-835-1394-0

6234
4

AGARD
NATO OTAN
7 RUE ANCELLE · 92200 NEUILLY-SUR-SEINE
FRANCE
Telephone 745.08.10 · Telex 610176

DISTRIBUTION OF UNCLASSIFIED AGARD PUBLICATIONS

AGARD does NOT hold stocks of AGARD publications at the above address for general distribution. Initial distribution of AGARD publications is made to AGARD Member Nations through the following National Distribution Centres. Further copies are sometimes available from these Centres, but if not may be purchased in Microfiche or Photocopy form from the Purchase Agencies listed below.

NATIONAL DISTRIBUTION CENTRES

BELGIUM
Coordonnateur AGARD – VSL
Etat-Major de la Force Aérienne
Quartier Reine Elisabeth
Rue d'Evere, 1140 Bruxelles

CANADA
Defence Science Information Services
Department of National Defence
Ottawa, Ontario K1A OK2

DENMARK
Danish Defence Research Board
Østerbrogades Kaserne
Copenhagen Ø

FRANCE
O.N.E.R.A. (Direction)
29 Avenue de la Division Leclerc
92320 Châtillon sous Bagneux

GERMANY
Fachinformationszentrum Energie,
Physik, Mathematik GmbH
Kernforschungszentrum
D-7514 Eggenstein-Leopoldshafen 2

GREECE
Hellenic Air Force General Staff
Research and Development Directorate
Holargos, Athens

ICELAND
Director of Aviation
c/o Flugrad
Reykjavik

ITALY
Aeronautica Militare
Ufficio del Delegato Nazionale all'AGARD
3, Piazzale Adenauer
Roma/EUR

LUXEMBOURG
See Belgium

NETHERLANDS
Netherlands Delegation to AGARD
National Aerospace Laboratory, NLR
P.O. Box 126
2600 A.C. Delft

NORWAY
Norwegian Defence Research Establishment
Main Library
P.O. Box 25
N-2007 Kjeller

PORTUGAL
Direcção do Serviço de Material
da Forca Aerea
Rua da Escola Politécnica 42
Lisboa
Attn: AGARD National Delegate

TURKEY
Department of Research and Development (ARGE)
Ministry of National Defence, Ankara

UNITED KINGDOM
Defence Research Information Centre
Station Square House
St. Mary Cray
Orpington, Kent BR5 3RE

UNITED STATES
National Aeronautics and Space Administration (NASA)
Langley Field, Virginia 23365
Attn: Report Distribution and Storage Unit

THE UNITED STATES NATIONAL DISTRIBUTION CENTRE (NASA) DOES NOT HOLD STOCKS OF AGARD PUBLICATIONS, AND APPLICATIONS FOR COPIES SHOULD BE MADE DIRECT TO THE NATIONAL TECHNICAL INFORMATION SERVICE (NTIS) AT THE ADDRESS BELOW.

PURCHASE AGENCIES

Microfiche or Photocopy
National Technical
Information Service (NTIS)
[illegible]
[illegible]

Microfiche
Space Documentation Service
European Space Agency
10, rue Mario Nikis
75015 Paris, France

Microfiche
Technology Reports
Centre (DTI)
Station Square House
St. Mary Cray
Orpington, Kent BR5 3RF
England

Requests for photocopies of AGARD documents should include the AGARD serial number, title, author or editor, and publication date. Requests to NTIS should include the NASA accession report number. Full bibliographical references and abstracts of AGARD publications are given in the following journals:

Scientific and Technical Aerospace Reports (STAR)
published by NASA Scientific and Technical
Information Facility

Government Reports Announcements (GRA)
published by the National Technical
Information Services, Springfield
Virginia 22161, USA

Printed by Technical Editing and Reproduction Ltd
Harford House, 7–9 Charlotte St, London W1P 1HD

ISBN 92-835-1394-0